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U.S. Federal Research on Fisheries and Limnology in the Great Lakes through 1964: An Annotated Bibliography

By Ralph Hile

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RALPH HILE

United States Fish and Wildlife Service
Special Scientific Report--Fisheries No. 528

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CONTENTS

	Page
Introduction	1
The research program, 1957-64	1
Sea lamprey	1
Fisheries and limnology	4
Publications by staff members	5
Publications by scientists associated with Great Lakes Fishery Investigations	46
Patents and patent applications	50
United States	50
Canada	52
Scientific staff, December 31, 1964	52

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By

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ABSTRACT

The annotated bibliography is preceded by a brief account of the Federal research program in fisheries and limnology in the Great Lakes in 1957-64. The bibliography covers 314 papers by staff members of the Bureau of Commercial Fisheries Biological Laboratory in Ann Arbor, Mich., and 35 by associated scientists with whom the Laboratory had contractual or other cooperative arrangements; included also are patents issued to Laboratory personnel. A roster of Laboratory scientists as of December 31, 1964, is appended.

INTRODUCTION

This publication is the third of a series on Federal research on fisheries and limnology in the Great Lakes. The first report, "25 Years of Federal Fishery Research on the Great Lakes," was issued in October 1952 (Special Scientific Report--Fisheries No. 85) and the second, "U.S. Federal Fishery Research on the Great Lakes through 1956," appeared in October 1957 (Special Scientific Report--Fisheries No. 226).

Each of these earlier annotated bibliographies of publications by staff members of the Bureau of Commercial Fisheries Biological Laboratory in Ann Arbor[1] carried also an account of the research programs, including federally supported studies by Walter N. Koelz and John Van Oosten preceding the formal establishment of the Laboratory in 1927. This third bibliography is complete through 1964, but descriptions of research programs are limited to a brief review of developments after 1956. Those interested in the account of earlier researches should consult the second of the two preceding reports.

[1] Federal fishery research on the Great Lakes has been carried out under three agencies. The Bureau of Fisheries was combined with the Bureau of Biological Survey to form the Fish and Wildlife Service in 1940. The Fish and Wildlife Service was subdivided in 1956 into its present components, the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife. The designation Bureau of Commercial Fisheries, Biological Laboratory, Ann Arbor, replaced the former Great Lakes Fishery Investigations in 1959. To avoid confusion, the most recent names are used throughout this publication.

THE RESEARCH PROGRAM, 1957-64

Calendar year 1957 was eventful for the Bureau's Biological Laboratory at Ann Arbor. It was the first full year in which research on and experimental control of the sea lamprey were carried out under contract with the Great Lakes Fishery Commission; it was also the year in which fishery research was strengthened by the establishment of Biological Stations on Lake Erie at Sandusky, Ohio, and on Lake Superior at Ashland, Wis. The sea lamprey unit opened also a field station in Oconto, Wis., in 1957 but closed it in 1960 when it was determined that the Lake Michigan work could be carried out more efficiently from existing stations at Marquette, Mich., and Ludington, Mich. The Biological Station at Marquette had operated continuously since 1950. The one at Ludington was established in 1956.

Because of their independent budgeting, the two major phases of the Laboratory's work in 1957-64 (sea lamprey research and control, and general fishery research program) are treated separately.

Sea Lamprey

Experimental control of the sea lamprey entered a new phase in October 1957 with the first field test, on a Lake Huron tributary, of a selective larvicide in the halogenated nitrophenol series (3, 4, 6-trichloro-2-nitrophenol). An additional test in early 1958 with the same chemical and two tests with 3-trifluoromethyl-4-nitrophenol (TFM), all in Lake Superior tributaries, ended the test series. The

unqualified success of all four trials permitted the release of the compounds for use in an experiment to reduce stocks of sea lampreys, first in Lake Superior and then in the lower Lakes. Of the two compounds, TFM was selected for general use because of the lesser quantities required to achieve concentrations lethal to sea lampreys.

The discovery and development for practical field use of toxicants that could destroy sea lampreys without inflicting significant damage on other fishes was the culmination of 4 years of research at the Biological Station in Hammond Bay (established in 1950) on northern Lake Huron. Thousands of chemicals were evaluated. When the selective properties of halogenated nitrophenols were discovered, these properties of physiological effects of the compounds were studied in series of detailed bioassays. Next, tests were completed in raceways before trials in natural streams were undertaken.

The development and subsequent field use of a selective larvicide placed the staff of the sea lamprey unit temporarily in the unhappy position of operating at considerable cost along two lines, one of which almost certainly would be abandoned. Before the selective toxicant was discovered, the one available method that gave promise of effective control was the blocking of spawning runs of sea lampreys by electrical barriers installed in streams below the spawning areas. This control method had the major shortcoming that no results in terms of a reduction of parasitic-phase sea lampreys in a lake could be expected until all spawning streams of a lake had been blocked 4 to 7 years, the apparent length of larval life in the stream. The barriers also had operational weaknesses. Their effectiveness was influenced greatly by details of installation that had to be worked out stream by stream; on occasion, extensive and costly modifications or new installations were required. The barriers also rarely blocked the run completely. Operations were interrupted occasionally despite the precaution of standby generators intended to start automatically when the regular power source was interrupted. More damaging were abnormally high stream levels which could make the traps on structures ineffective from a few hours to as long as several weeks. Still another difficulty that required much attention was the mortality of fish at some barriers. These kills were reduced somewhat by improvements of barrier design but more importantly by the development and installation in the more troublesome streams of a direct-current (DC) diversion device situated just downstream from the main alternating-current (AC) barrier.

During much of the period when the construction and operation of electrical barriers were being improved toward maximum efficiency and new units were being added to the barrier systems, the work was carried on with full knowledge that electrical control might soon be superseded by chemical control. The extensive equipment, except that required to monitor changes in sea lamprey stocks, would then be surplus hardware. Yet, no choice existed; a control method of known promise could not be abandoned until the soundness of the alternative chemical control could be established beyond reasonable doubt.

As the chemical treatments of streams expanded, barrier operations were reduced (table 1). After 1960, the electric barriers served solely as monitoring devices. Barriers on Lake Michigan were reduced to three to save money for use in chemical treatments. Now that treatments are well advanced on Lake Michigan the number of barriers is to be increased to at least six to provide broader coverage.

The chemical treatments did not proceed without certain difficulties and failures. The development and handling of proportioning equipment raised problems, and field procedures had to be worked out for pretreatment surveys and bioassays, the actual treatment, and the posttreatment check. Causes of failures needed to be learned and remedies developed. A few of the early treatments had to be repeated, but continued experience largely eliminated failures and led to a highly efficient routine. Among the major advances were the construction of mobile bioassay laboratories, the development of rapid and accurate procedures for determination of the concentration of larvicides in stream water, the fabrication of equipment for the automatic recording of the passage of dye used in studies of stream flow, and the establishment of effective radio communication among groups engaged in the treatment of large stream systems.

The personnel of the control unit, indeed the entire staff of the Biological Laboratory at Ann Arbor awaited anxiously the final proof of the effectiveness of chemical control on Lake Superior in the form of sharply reduced catches of spawning-run sea lampreys at the electric barriers. Enough streams had been treated by 1961 to raise some hope of a decrease of the run that year; the 1961 run actually was at a record high of 67,230 lampreys (table 2). The real drop came in 1962 when the total catch of lampreys (9,122 individuals) declined 84.4 percent from the preceding year. This new low level continued in 1963 and 1964.

Even though the sea lamprey stock of Lake Superior should be and, it is hoped, can be reduced further, the present control clearly has benefited the lake trout populations. The lake trout stocks, bolstered by large-scale planting of fingerlings, have reached levels of abundance in some parts of Lake Superior equal to those in years preceding the lamprey's penetration into the Lake. Abundance of lake trout is not equally great in other areas but is increasing

Table 1.--Numbers of electrical barriers operated and numbers of streams treated chemically for the control of the sea lamprey in Lakes Superior, Michigan, and Huron, 1953-64

Year	Lake Superior			Lake Michigan			Lake Huron
	Barriers		Streams treated[2]	Barriers		Streams treated	Streams treated[3]
	AC	DC[1]		AC	DC[1]		
1953	10	--	--	--	--	--	--
1954	44	--	--	7	--	--	--
1955	36	--	--	17	--	--	--
1956	35	2	--	19	--	--	--
1957	39	7	--	37	--	--	1
1958	45	11	10-0	63	3	--	1
1959	40	11	28-1	37	2	--	--
1960	36	11	15-1	19	1	7-0	--
1961	29	9	1-7	3	--	26-0	1
1962	29	9	5-14	3	--	8-0	2
1963	26	9	8-17	3	--	22-0	--
1964	22	8	8-17	4	1	15-12	--

[1] These DC diversion barriers were installed downstream from the standard AC barriers.

[2] The first of the paired figures is the number of streams receiving the initial application of the chemical, and the second is the number of reapplications. Part of the early reapplications corrected faulty first treatments; all others were made to destroy reestablished stocks of ammocetes.

[3] No reapplications.

Table 2.--Numbers of spawning-run sea lampreys captured at electrical barriers in 22 tributaries of Lake Superior, 1959-64

Year	Sea lampreys
	Number
1959	44,028
1960	36,774
1961	67,230
1962	9,122
1963	11,111
1964	11,961

rapidly in all sections of the Lake. It is clearly established that the sea lamprey has been brought under control sufficiently well to permit once more a good abundance of lake trout. Similar results are to be anticipated in Lakes Michigan and Huron when stream treatments have been completed there.

The search for selective toxicants did not end at the Biological Station in Hammond Bay when TFM was released for field use. New compounds still are screened in an attempt to find cheaper and more effective materials; even now "second-order" tests are in progress with one family of chemicals that offers considerable promise. The Station also continues to test the quality of all shipments of larvicides supplied by chemical firms for the control program.

The Hammond Bay staff, despite continuation of certain duties, was able to broaden its program to include the study of several practical problems and an expansion of research on the biology of the lamprey itself. Among their projects should be mentioned: study of seasonal changes of water quality that influence the biological activity of larvicides; determination of the effects of TFM on warm-water species of fish; development of a synergistic mixture of TFM and a molluscicide that reduces costs of treatment; description of embryological stages of all species of lampreys resident in the Great Lakes; determination of the effects of temperature on the embryological development of the sea lamprey; studies of feeding and growth of ammocetes; and determination of biological characteristics of recently transformed sea lampreys.

Still another significant research project, carried on by the staff at the Biological Station in Marquette is the study of a single year class of sea lampreys established in a section of stream above an impassable barrier. These animals which had completed 4 growing seasons

at the end of 1964 will provide information on growth, length of larval life, and period of transformation to the parasitic phase.

Fisheries and Limnology

Two of the most serious gaps in the research program were partially filled by the establishment of Biological Stations on Lakes Erie and Superior. No work of consequence had been carried out on Lake Erie since 1930 although the commercial landings at selected ports had been sampled each fall, beginning in 1943. The Lake Superior fisheries received some attention in 1950-52, but the reassignment of the staff of the Biological Station at Marquette to sea lamprey control forced reduction of the fishery work to annual sampling of the spawning run of lake herring at major ports and limited observations on the lake trout fishery.

The Lake Erie staff at Sandusky was confronted with complex and difficult problems. The fishery was well advanced in the decline that was to carry two of the major "money" fish, blue pike and whitefish, to the verge of extinction and reduce the take of a third, the walleyè, to a small fraction of its former level. A feature of the deteriorating fishery appeared to be erratic and violent fluctuations of year classes. The cause or causes of the declinations were unknown, but evidence was strong that the rapidly increasing pollution from domestic and industrial wastes was creating a more and more unfavorable habitat. It was necessary, therefore, to give close attention both to the Lake and to the various species of fish that live in it.

To help the Sandusky staff, the research vessel Cisco was assigned to Lake Erie for a lakewide survey in 1957 and a more intensive study of the productive western end in 1958. At the same time, the vessel Musky was transferred from Hammond Bay to Sandusky. The two vessels, working together, completed a reasonably sound preliminary study of fish stocks and limnological conditions.

Vessel problems plagued the Sandusky staff at the end of the 1958 season, when the Musky had to be stripped and the badly deteriorated hull destroyed. A chartered trap net boat, the George L., gave far from adequate service in 1959 and most of 1960. In the fall of 1960 a new steel hull was purchased, engines and gear from the former Musky were installed, and the Musky II, a most satisfactory research vessel, was put into service.

The research on Lake Erie has followed three main lines. Experimental fishing, mostly by trawl in the western part, gives annual measures of the abundance of fish--especially of the 0 group; the trawling was designed to give a basis for statistical judgment on the reliability of the records as measures of relative abundance of individual species. A second project has been the continuation on a broader and sounder basis of the sampling of commercial landings that was in effect before the Station was established. The third major line of study (much of it in collaboration with the Environmental Research Program) concerns the environment of the Lake with particular reference to the ecological requirements of major species. Since the Green Bay and Saginaw Bay projects terminated in 1964, the staff at Sandusky has assumed responsibility for the collection of data from the commercial fisheries of the two Bays.

The staff at the new Lake Superior station at Ashland, like the one at Sandusky, suffered initially from the lack of a good research vessel. The Siscowet, which was transferred from Marquette, required extensive modifications that were not completed until near the end of the 1958 season. The reconstructed Siscowet is a sound, seaworthy craft equipped for both fishery and limnological research. Most work of the Siscowet has been in the Apostle Islands region, but annual cruises have been made to the northern (Isle Royale and Canadian North Shore) and central (Keweenaw Bay and the Marquette area) regions.

The fishery program on Lake Superior has concentrated along three major lines--research on lake trout over a wide field, analysis of commercial landings of major species, and studies on composition and distribution of fish populations and related limnological conditions.

Lake trout research includes both the study of the commercial landings (coverage is now almost complete) and investigations by the Siscowet. Commercially caught lake trout are examined for size, age, maturity, food, incidence of lamprey wounds and scars, and origin (natural and hatchery). Work by the Siscowet is concentrated on the early life history (especially through the first 3 to 4 years): abundance of native and hatchery-reared young; movements, distribution, growth, and survival of planted fingerlings. The Siscowet also obtains records for larger fish and makes annual checks of the abundance of adult lake trout on spawning reefs.

The sampling of other commercially landed fish is directed principally at whitefish and lake herring in areas of greatest production. Annual changes and local differences of growth and year-class composition are followed.

The Siscowet collects limnological data and materials routinely and to meet special needs; limnological "index" stations are visited on schedule. The Siscowet's experimental fishing yields information and materials on the distribution, abundance, movements. . . of a wide variety of species. In 1959, the Siscowet's work was supplemented by the Cisco's survey of eastern Lake Superior.

The return of the Cisco to Lake Michigan in 1960 made possible the resumption of work on

the deepwater fishes of that Lake. Particular attention was given to progressive changes in cisco stocks, the expansion of alewife stocks, and the distribution and habits of larval fishes. Limnological observations also were resumed.

An important phase of research on coregonids has been the artificial rearing of young of known parentage at the Biological Station in Northville (a former Federal hatchery near Ann Arbor). The project was set up in an attempt to find characters for the field identification of young ciscoes (separation by species usually is impossible at lengths less than 7 inches). The success in rearing was surprisingly good, and much valuable information was accumulated, but attainment of the original goal seems unlikely. The station was closed in early 1964.

Environmental research on the Great Lakes has been handicapped by the lack of a specially designed and equipped limnological vessel. Staff members of the Environmental Program have worked regularly with fishery research programs and have obtained extensive materials and data from the fishery research vessels. From this cooperative arrangement have come numerous and significant advances in knowledge and understanding of the physical and chemical characteristics of Great Lakes waters, currents and seiches, plankton, bottom fauna. . . . The joint study of the fisheries and limnology of Lake Erie is proving most valuable to the environmental unit and the Lake Erie staff in demonstrating better the effects of the increasing pollution of the Lake.

The tabulation of statistics on production of all species and on catch, effort, and catch per unit of effort for principal species in the different areas (statistical districts) of the Great Lakes has continued uninterrupted. The Biological Laboratory at Ann Arbor now carries out this work for seven States; the eighth State and the Province of Ontario compile their own records by procedures developed in the Laboratory. These statistical records are providing increasingly valuable background for the expanding biological researches.

PUBLICATIONS BY STAFF MEMBERS

The following list includes the principal publications of staff members of the Bureau of Commercial Fisheries Biological Laboratory in Ann Arbor. Omitted have been papers resulting from work not associated with Great Lakes research, reviews, and numerous processed memoranda and informational releases of only temporary value, prepared for administrative use, or given restricted distribution. The list does include a number of publications of a popular character prepared for the information of the general public and the fishing industry; most of these popular articles contain illustrative original materials drawn from the Great Lakes files or are summaries of longer papers issued in scientific publications not generally accessible.

Reports on researches completed under contract are listed here if staff members of the Laboratory participated closely in the planning and conduct of the study and the preparation of the final report. Reports on contract research completed more or less independently of the Laboratory are listed in the later section on publications by associated scientists.

ADAMS, W. C., vide: JOHN VAN OOSTEN.

ALLEN, HERBERT E.

1964. Chemical characteristics of south-central Lake Huron. In Proc. 7th Conf. Great Lakes Res., p. 45-53. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 11.

Contains data on temperature, pH, conductivity, and concentrations of Na, K, Ca, Cl, SO_4, SiO_2, and dissolved oxygen off the mouth of Saginaw Bay and along a transect from Harbor Beach, Mich., to Goderich, Ontario, June-October 1956. Chemical composition did not vary with season or depth. Outflow from Saginaw Bay sometimes caused large increases in concentrations of chemicals in surface waters.

ANDERSON, GAYLORD A.

1962. Three portable feeders for metering chemical into streams for control of sea lamprey. Progr. Fish-Cult. 24(4): 190-192.

Three lightweight, readily portable metering devices were developed for application of selective larvicides in small streams--gravity feeder, fuel-pump feeder, and electric-pump feeder. The construction and use of each type are described; photographs of the devices are included.

APPLEGATE, VERNON C.

1950. Natural history of the sea lamprey, Petromyzon marinus, in Michigan. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 55, xii + 237 p.

Exhaustive study of life history from deposition and hatching of eggs, through 4-year larval existence, metamorphosis, 1- to 1-1/2-year parasitic stage in lake, upstream spawning migration, and nest building. Contains voluminous ecological data on factors of migration, spawning requirements, larval habitat. . . .

APPLEGATE, VERNON C.

1951a. Sea lamprey investigations. II. Egg development, maturity, egg production, and percentage of unspawned eggs of sea lampreys, Petromyzon marinus,

captured in several Lake Huron tributaries. Pap. Mich. Acad. Sci. Arts Lett. 35(pt. 2):71-90.

Investigation of sex cycle of females--sizes of eggs, number per individual (range of 24,000 to 110,000; mean of 61,500) and its variation with body length and weight, and percentage of unspawned eggs (estimated at 5.0).

APPLEGATE, VERNON C.
1951b. The sea lamprey in the Great Lakes. Sci. Mon. 72(5):275-281.

Semipopular account of the invasion of the upper Great Lakes by the sea lamprey and of the effects of that parasite on stocks of commercially valuable fish. Reviews sea lamprey's life history with special reference to technical problems of control.

APPLEGATE, VERNON C.
1961. Downstream movement of lampreys and fishes in the Carp Lake River, Michigan. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 387, iv + 71 p.

Presentation, largely in tabular form, of records of catches of lampreys and other fishes at an inclined-screen trap operated almost continuously in the Carp Lake River, 1948-58. Principal tables give daily records of catch of recently transformed sea lampreys, along with information on water level, temperature, and weather, for the migration seasons 1951-52 through 1957-58 (data for earlier seasons published previously). Semimonthly catch records for fishes other than lampreys are given for seasons 1948-49 through 1957-58. Other tables give information on length and weight of recently transformed and larval lampreys.

APPLEGATE, VERNON C., and CLIFFORD L. BRYNILDSON.
1952. Downstream movement of recently transformed sea lampreys, Petromyzon marinus, in the Carp River, Michigan. Trans. Amer. Fish. Soc. 81:275-290.

Three-year count of daily catch of newly transformed migrants captured by inclined-plane screen and trap. Includes data on sizes of migrants and evidence of rise in stream water level as major factor inducing migration.

APPLEGATE, VERNON C., JOHN H. HOWELL, A. E. HALL, JR., and MANNING A. SMITH.
1957. Toxicity of 4,346 chemicals to larval lampreys and fishes. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 207, ii + 157 p.

List of chemicals and record of their effects on ammocetes, rainbow trout, and bluegills of various low concentrations of chemicals; temperature, 55° F. These tests represent the preliminary work in a search for a means of destroying larval lampreys in streams through the addition of chemicals.

APPLEGATE, VERNON C., JOHN H. HOWELL, JAMES W. MOFFETT, B. G. H. JOHNSON, and MANNING A. SMITH.
1961. Use of 3-trifluormethyl-4-nitrophenol as a selective sea lamprey larvicide. Great Lakes Fish. Comm., Tech. Rep. 1, 35 p.

Historical account of researches--bioassays, raceway tests, and experimental stream treatments--that preceded the general field use of the compound for control of the sea lamprey. Procedures and results are described for bioassays and raceway tests, and a detailed account is given of the experimental treatment of each of four Lake Superior tributaries (three in the United States and one in Canada). The relations of the biological activity of TFM to temperature and the physical and chemical characteristics of water are reviewed.

APPLEGATE, VERNON C., JOHN H. HOWELL, and MANNING A. SMITH.
1958. Use of mononitrophenols containing halogens as selective sea lamprey larvicides. Science 127(3294):336-338.

Account of the screening experiments that led to the discovery of the selective toxicity that permits use of chemicals of the mononitrophenol group to destroy larval sea lampreys without significant injury to other fishes. Includes tabular presentation for six mononitrophenols of concentrations required to kill ammocetes and to inflict significant mortality on rainbow trout, brown trout, and bluegills.

APPLEGATE, VERNON C., and EVERETT L. KING, JR.
1962. Comparative toxicity of 3-trifluormethyl-4-nitrophenol (TFM) to larval lampreys and eleven species of fishes. Trans. Amer. Fish. Soc. 91(4):342-345.

TFM was selectively toxic toward larval lampreys in tests with rainbow trout and 10 warm-water fish species. Toxicity varied widely with the conductivity and alkalinity of the dilution waters, but selective action persisted at all levels. Smallmouth bass and other centrarchids were most tolerant of

TFM; walleyes, yellow perch, bullheads, and white suckers were most susceptible.

APPLEGATE, VERNON C., PAUL T. MACY, and VIRGIL E. HARRIS.
1954. Selected bibliography on the applications of electricity in fishery science. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 127, ii + 55 p.

Contains: citations of 350 publications in the worldwide literature, including sources of abstracts and reviews of some; titles of 27 typewritten or processed reports, and locations of agencies with which they are deposited; and list of 22 patents issued by the U.S. Patent Office.

APPLEGATE, VERNON C., and JAMES W. MOFFETT.
1955a. Sea lamprey and lake trout. In Scientific American editors, First book of animals, p. 9-16. Simon and Schuster, New York.

Review of: sea lamprey's invasion and spread through the upper Great Lakes; life history of the sea lamprey; its impact on fish populations with special reference to lake trout; research aimed at the development of control methods.

APPLEGATE, VERNON C., and JAMES W. MOFFETT.
1955b. The sea lamprey. Sci. Amer. 192(4): 36-41.

Concise review of the sea lamprey problem and of research and control operations directed toward its solution. Includes illustrations and diagrams on: spread of the sea lamprey; life cycle; effects on the lake trout fishery; electrical control devices.

APPLEGATE, VERNON C., and BERNARD R. SMITH.
1950. Sea lamprey spawning runs in the Great Lakes in 1950. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 61, iv + 49 p.

Records of numbers, sex ratio, sizes . . . of adults and recently transformed sea lampreys captured in experimental weirs and traps operated in various streams tributary to Lakes Michigan, Huron, and Superior. [Actually issued in 1951.]

APPLEGATE, VERNON C., and BERNARD R. SMITH.
1951. Movement and dispersion of a blocked spawning run of sea lampreys in the Great Lakes. Trans. 16th N. Amer. Wildl. Conf.:243-251.

Analysis of data on 289 recoveries from 2,843 sea lampreys tagged after capture below a dam in the Cheboygan River (tributary to Straits of Mackinaw). Lampreys lack "homing" instinct.

APPLEGATE, VERNON C., BERNARD R. SMITH, ALBERTON L. McLAIN, and MATT PATTERSON.
1952. Sea lamprey spawning runs in the Great Lakes, 1951. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 68, ii + 37 p.

Record for 1951 similar to that for 1950 (Applegate and Smith, 1950). Includes data on annual trends in numbers, sizes, and sex ratio of runs.

APPLEGATE, VERNON C., BERNARD R. SMITH, and WILLIS L. NIELSEN.
1952. Use of electricity in the control of sea lampreys: electromechanical weirs and traps and electrical barriers. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 92, iv + 52 p.

Account of 1951-52 experiments with electrical barriers for blocking sea lamprey spawning runs. Describes installation and operation of four devices and their effects on sea lampreys and fish. Summarizes the problem of adapting construction and operation according to local stream conditions.

APPLEGATE, VERNON C., vide: MANNING A. SMITH.

AYERS, JOHN C., vide: CHARLES F. POWERS.

BAILEY, MERRYLL M.
1963. Age, growth, and maturity of round whitefish of the Apostle Islands and Isle Royale regions, Lake Superior. U.S. Fish Wildl. Serv., Fish. Bull. 63:63-75.

Round whitefish averaged older (6.0 years) at Isle Royale than in the Apostle Islands (4.2 years). In both areas, nearly or fully 7 years were required for attainment of an acceptable commercial length of 14 inches. The body-scale relation was linear with an intercept of 1.1 inches on the axis of fish length. Weight increased as the 3.22 power of the length. Youngest mature fish belonged to age-group II; all males older than the IV group and all female older than the V group were mature. Males dominated the younger age

groups, but females were more numerous in the older ones. Mean number of eggs was 5,330 for 37 females 10.5-17.4 inches long.

BAILEY, MERRYLL M.
1964. Age, growth, maturity, and sex composition of the American smelt, Osmerus mordax (Mitchill), of western Lake Superior. Trans. Amer. Fish. Soc. 93(4):382-395.

Collections of 4,561 smelt provided information on various phases of the life history. The presence of the first annulus (sometimes lacking in slowly growing stocks) was established, and a body-scale relation was determined. Time of annulus formation extends from early or mid-June to past the middle of August. Weight increased as the 2.952 power of the length. Best annual growth in length (3.3 inches) was in the second year. Best growth in weight was in the third (0.74 ounce, males; 0.85 ounce, females). Growth of females was distinctly better than that of males beyond the third year. Shortest mature smelt of each sex were at 5.0-5.2 inches, but males are first to reach 100-percent maturity. All year-old smelt were immature. Among 2-year-olds, 40.7 percent of the males and 17.7 percent of the females were mature. Older fish of both sexes were mature. Ovaries of 10 smelt, 7.3 to 8.8 inches long, contained an average of 31,338 eggs.

BAILEY, REEVE M., vide: PAUL H. ESCHMEYER.

BEETON, ALFRED M.
1958. Relationship between Secchi disc readings and light penetration in Lake Huron. Trans. Amer. Fish. Soc. 87:73-79.

Paired photometer and Secchi disk measurements at 18 localities in Saginaw Bay and Lake Huron proper supported views based on other evidence on movements of clear lake water into and out of the Bay. Transmission of incident light averaged 14.7 percent at Secchi disk level. Discrepancies between photometer and disk measurements were attributed to sky and sea conditions.

BEETON, ALFRED M.
1959. Photoreception in the opossum shrimp, Mysis relicta Lovén. Biol. Bull. 116(2):204-216.

Mysis relicta has at least two visual pigments with absorption peaks at or below 3,950 angstroms and at 5,150 angstroms; the latter and stronger peak is most significant in orientation. Ability to "dark-adapt" quickly indicates rapid regeneration of visual purple. Mysis is photopositive unless kept in darkness 10 hours or longer; then it becomes photonegative.

BEETON, ALFRED M.
1960a. Great Lakes limnological investigations. In Proc. 3d Conf. Great Lakes Res., p. 123-128. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 4.

Federal limnological research in the Great Lakes in the 1950's is reviewed, and broad comments are offered on the characteristics of the Lakes and on evidence for change in certain areas, as western Lake Erie. Particular stress is laid on the importance of long-term and continuing studies and on the value of interagency and interdisciplinary cooperation for attacks on problems beyond the capabilities of a single group.

BEETON, ALFRED M.
1960b. The vertical migration of Mysis relicta in Lakes Huron and Michigan. J. Fish. Res. Bd. Can. 17(4):517-539.

A preference for low light intensity keeps Mysis concentrated near the bottom by day. They move upward toward sunset as surface light decreases from 15 to 1 foot candle. This movement may carry them entirely through the metalimnion, but later in the night most are in or below that layer. They descend toward the bottom as light increases in the morning.

BEETON, ALFRED M.
1961. Environmental changes in Lake Erie. Trans. Amer. Fish. Soc. 90(2): 153-159.

Fish fauna, bottom fauna, and chemical conditions of Lake Erie have changed greatly over the past 60 years. Cisco and blue pike, once major commercial species, have almost disappeared. Midge larvae and oligochaetes have replaced Hexagenia as the dominant bottom organisms. Concentrations of major ions have increased as much as 10 p.p.m. Late-summer oxygen depletion is becoming more severe and affecting greater areas. All evidence points toward progressive eutrophication.

BEETON, ALFRED M.
1962. Light penetration in the Great Lakes. In Proc. 5th Conf. Great Lakes Res., p. 68-76. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 9.

Study is based on measurements of incident and subsurface light in each of the Great Lakes and in one small inland lake; at least one study was made of spectral distribution in each water. Colors that penetrated deepest were: Huron, blue; Superior and Michigan, green; Erie and Ontario, orange. Percentage penetration of incident irradiance was greatest at sunrise and sunset in Erie and Frains Lake, but at noon in Lake Michigan (no similar study in other waters).

BEETON, ALFRED M.
1963. Limnological survey of Lake Erie, 1959 and 1960. Great Lakes Fish. Comm., Tech. Rep. 6, 32 p.

Federal, Provincial, State, and university agencies made a cooperative limnological survey of central Lake Erie in September 1959 and lakewide in August 1960. Oxygen depletion was severe in bottom waters of about 70 percent of the central basin each year. Vertical temperature profiles and other physical and chemical data were collected. Factors of distribution of chemical values are discussed.

BEETON, ALFRED M., and DAVID C. CHANDLER.
1963. The St. Lawrence Great Lakes. In David G. Frey (editor), Limnology in North America, p. 535-558. Univ. Wis. Press, Madison.

A statement on the location, area, depth . . . and economic significance of the Great Lakes is followed by a brief review of their physical, chemical, and biological characteristics and comments on the fisheries. Principal section is a history of limnological research treated by three time periods: pre-1900; 1900-49; and 1950-62. Recent programs are discussed under headings: U.S. Bureau of Commercial Fisheries; U.S. Lake Survey; Great Lakes Research Division, The University of Michigan; University of Minnesota; Ontario Department of Lands and Forests; Great Lakes Institute, University of Toronto; U.S. Public Health Service; and other organizations.

BEETON, ALFRED M., and FRANK F. HOOPER.
1961. The hydrography of Saginaw Bay. [Abstract.] In Proc. 4th Conf. Great Lakes Res., p. 111. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 7.

Items studied in three synoptic surveys in 1956 are outlined. Broad comments are given on such matters as inflow of Lake Huron water, outflow of Saginaw Bay water, and flushing rates. Certain changes of flow patterns are described.

BEETON, ALFRED M., JAMES H. JOHNSON, and STANFORD H. SMITH.
1959. Lake Superior limnological data, 1951-1957. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 297, vi + 177 p.

Contains extensive tabulations of data on temperature (bathythermograph and recording thermograph), ion concentrations and other water characteristics (O_2, pH, specific conductance, total alkalinity, Ca, Mg, Na, SiO_2, P, N), and plankton (wet, dry, and ash weights). Some limited discussion of possible significance of records is offered.

BEETON, ALFRED M., and JAMES W. MOFFETT.
1964. Lake Michigan chemical data, 1954-55, 1960-61. U.S. Fish Wildl. Serv., Data Rep. 6, 3 microfiches (i + 102 p.).

Tabulations of data (surface water and samples in vertical series) on determinations of Na, Ca, K, Mg, SiO_2, SO_4, Cl, P (total), and conductivity.

BEETON, ALFRED M., vide: S. L. DANIELS, L. L. KEMPE, J. S. MARSHALL, LaRUE WELLS.

BEIL, JOSEPH, vide: WILLIAM R. DRYER.

BRAEM, ROBERT A., and WESLEY J. EBEL.
1961. A back-pack shocker for collecting lamprey ammocoetes. Progr. Fish-Cult. 23(2):87-91.

Gives detailed instructions and diagrams for the construction and use of a lightweight (25 pounds) unit that is especially valuable for collecting in small streams.

BRYNILDSON, CLIFFORD L., vide: VERNON C. APPLEGATE.

BUETTNER, HOWARD J.
1961. Recoveries of tagged, hatchery-reared lake trout from Lake Superior. Trans. Amer. Fish. Soc. 90(4):404-412.

To measure possible survival benefits from longer retention in the hatchery, 13,384 hatchery-reared lake trout were tagged by four methods and planted at the ages of 18, 25, 30, and 37 months. Recoveries increased with age at planting but not enough to justify the cost of longer rearing. Rates of return were similar for fish planted in the spring and in the fall. Percentages of recovery were similar (3.9 to 4.8 percent) for lower-jaw and two types of nylon-streamer tags; the recovery rate was much higher (12.4 percent) for Petersen tags.

BUETTNER, HOWARD J., vide: RALPH HILE; STANFORD H. SMITH.

CABLE, LOUELLA E.
1950. A cheek tag for marking fish, with semi-automatic pliers for application of tag. J. Cons. 16(2):185-191.

Description of tag, composed of steel rivet and plastic disk, and of pliers designed for its application.

CABLE, LOUELLA E.
1956. Validity of age determination from scales, and growth of marked Lake Michigan lake trout. Fish Wildl. Serv., Fish. Bull. 57:ii + p. 1-59.

The structure and growth of lake trout scales are described and illustrated by a series of photographs. The general validity of the annulus as a year-mark is established by scales of fish of known ages recovered from plantings of fin-clipped fingerlings made in Lake Michigan in 1944, 1945, and 1946. Included also are data and discussion on: growth of marked fish; factors of discrepancies of calculated growth; time of annulus formation; progress of season's growth; and length-weight relation.

CARR, IRA A.
1962. Distribution and seasonal movements of Saginaw Bay fishes. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 417, iv + 13 p.

Shore seining and fishing with trawls and gill nets from the M/V Cisco at 21 stations took 47 of the 74 species of fish known to occur in Saginaw Bay. No new species records were obtained, but locality records were greatly increased. Data are given on seasonal differences in the bathymetric distribution and areal abundance of the three most plentiful species: alewife, smelt, and yellow perch.

CARR, JOHN F.
1962. Dissolved oxygen in Lake Erie, past and present. In Proc. 5th Conf. Great Lakes Res., p. 1-14. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 9.

Differences of technique and distribution of samples hamper precise comparisons of dissolved-oxygen conditions in recent and earlier years. It appears, nevertheless, that oxygen deficiencies in bottom water have increased greatly since the late 1920's and early 1930's. At present, hundreds of square miles may lack detectable oxygen in bottom waters. Deficiencies invariably are limited to water below the metalimnion.

CHANDLER, DAVID C., vide: ALFRED M. BEETON; J. S. MARSHALL.

CROWE, WALTER R., ERNEST KARVELIS, and LEONARD S. JOERIS.
1963. The movement, heterogeneity, and rate of exploitation of walleyes in northern Green Bay, Lake Michigan, as determined by tagging. In North Atlantic Fish Marking Symposium, p. 38-41. Int. Comm. Northwest Atl. Fish., Spec. Publ. 4.

Recoveries of walleyes marked with jaw and spaghetti-dart tags in 1957-60 proved that the fish remained in northern Green Bay. Members of discrete spawning groups return annually to the same spawning grounds but are mixed at other seasons. The commercial catch in 1958 was estimated at 119,000 fish; sport fishermen took an estimated 420,000 fish.

CROWE, WALTER R., vide: PAUL H. ESCHMEYER.

DALY, RUSSELL, vide: PAUL H. ESCHMEYER.

DANIELS, S. L., L. L. KEMPE, E. S. GRAHAM, and A. M. BEETON.
1963. Quantitation of microorganic compounds in waters of the Great Lakes by adsorption on activated carbon. In Proc. 6th Conf. Great Lakes Res., p. 118-123. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 10.

Microorganic compounds adsorbed on activated charcoal filters from Lake Michigan and Lake Huron water were eluted by chloroform and alcohol. On the assumption that chloroform eluates represent less polar compounds from industrial sources and alcohol eluates the more polar varieties of natural origin, plots of the one against the other aid in judging water quality. Despite certain seasonal fluctuations it appears that northern Lake Michigan and Lake Huron in the vicinity of Saginaw Bay are relatively free of pollution.

DANIELS, STACY, vide: L. L. KEMPE.

DEASON, HILARY J.
1932a. A study of surface currents in Lake Michigan. The Fisherman (Grand Haven, Mich.) 1(5):3-4, 12.

Summary of information on direction and speed of surface currents obtained from recoveries of 180 of the 283 drift bottles released from the research vessel Fulmar, June-August 1931.

DEASON, HILARY J.
1932b. Scientific investigation of chubnet fishing in Lake Michigan. The Fisherman (Grand Haven, Mich.) 1(4):3-4, 11-12.

Description of organization and program of researches carried out from the research vessel Fulmar in cooperation with the States of Michigan and Wisconsin and four net manufacturers, and statement of principal goal as determination of mesh size most suitable for exploiting chubs and least harmful to immature lake trout.

DEASON, HILARY J.
1933a. Feeding adaptations in fishes. The Fisherman (Grand Haven, Mich.) 2(7): 3-4, 10-11.

Anatomical comparison of various types of feeding mechanism of fishes.

DEASON, HILARY J.
1933b. Geological formation of Great Lakes. The Fisherman (Grand Haven, Mich.) 2(3):3-4, 10.

Review of major stages and drainage patterns in the geological history of the Great Lakes.

DEASON, HILARY J.
1933c. Preliminary report on the growth rate, dominance, and maturity of the pike-perches (Stizostedion) of Lake Erie. Trans. Amer. Fish. Soc. 63: 348-360.

Comparison of growth of walleyes, blue pike, and sauger. Includes also data on dominance of the 1926 year class and on size at maturity for the three species.

DEASON, HILARY J.
1934. The development of fishes, tracing the natural developments from egg to fry. The Fisherman (Grand Haven, Mich.) 3(11):1, 3.

Description of embryological development based on eggs and fry of the walleye.

DEASON, HILARY J.
1935. Some general considerations of plankton and plankton problems with reference to water supplies. Mich. State Coll., Eng. Exp. Sta., Bull. 10(4):5-14.

General discussion of such matters as factors of plankton production, vertical distribution, seasonal abundance, relation of plankton growth to odors and tastes in water, and effect of pollution on plankton growth.

DEASON, HILARY J.
1936a. Bottles set adrift on Lake Michigan yield information on surface currents. Mich. Conserv. 6(6):9.

Review similar to that published by same author in 1932.

DEASON, HILARY J.
1936b. Upper Peninsula once bed of great inland sea. Mich. Conserv. 6(4):7, 11.

Brief popular account of certain stages of the glacial history of the Great Lakes region.

DEASON, HILARY J.
1939. The distribution of cottid fishes in Lake Michigan. Pap. Mich. Acad. Sci. Arts Lett. 24 (pt. 2):105-115.

Distributional study in which many of the locality records, particularly for deep-water species, were based on specimens recovered from stomachs of lake trout and burbot.

DEASON, HILARY J., and RALPH HILE.
1947. Age and growth of the kiyi, Leucichthys kiyi Koelz, in Lake Michigan. Trans. Amer. Fish. Soc. 74:88-142.

Comparative study for different regions of the Lake which revealed no

important differences in growth but a progressive increase from south to north in average age. Includes data on such questions as causes of discrepancies between calculated growth of different age groups, length of growing season, growth compensation, length-weight relation and condition (including seasonal fluctuations and regional differences), and sex ratio.

DEASON, HILARY J., vide: RALPH HILE; JOHN VAN OOSTEN.

DRYER, WILLIAM R.
1963. Age and growth of the whitefish in Lake Superior. U.S. Fish Wildl. Serv., Fish. Bull. 63:77-95.

Data on size, age and year-class composition, growth, and length-weight relation of whitefish from Bayfield, Wis., and Marquette, Whitefish Point, and Dollar Settlement, Mich. Growth rates, from fastest to slowest, were: Whitefish Point; Dollar Settlement and Marquette (the two reversed ranks after 3 years); Bayfield. The legal length of 17 inches was reached as early as the fourth year of life (Whitefish Point) and as late as the seventh (Bayfield). Differences of growth were largely established during the first 5 years of life. The body-scale ratio remained constant with increase of fish length. Weight increased as the 3.2408 power of length. Age and year-class composition fluctuated at the same port and differed among ports. The evidence suggests existence of a number of segregated stocks. At Bayfield, 51.5 percent of the fish were males, but males were scarce among fish older than the VIII group. All fish from Bayfield shorter than 14.5 inches were immature, and all longer than 17.4 inches were mature. The youngest mature fish belonged to age-group IV, and the oldest immature fish to age-group VII.

DRYER, WILLIAM R.
1964. Movements, growth, and rate of recapture of whitefish tagged in the Apostle Islands area of Lake Superior. U.S. Fish Wildl. Serv., Fish. Bull. 63:611-618.

Whitefish were tagged with spaghetti streamer tags in June and July 1960 (1,122 fish; 15.4 inches average length) and November 1959-61 (181 fish; 18.8 inches). Total recoveries were 374 fish (28.7 percent); most recaptures came within 2 years after tagging. Over half of the recoveries were within 5 miles of the tagging site, and the greatest distance traveled was 25 miles. Growth of fish tagged in June and July 1960 was 1.6 inches the first year and 1.2 the second. Of 27 fish recaptured within 6 months after tagging in November, 17 (63 percent) had decreased in length. Estimated annual exploitation rates were 22.6 percent for whitefish tagged in June and July and 20.5 percent for those tagged in November; true rates are believed to be higher.

DRYER, WILLIAM R., and JOSEPH BEIL.
1964. Life history of lake herring in Lake Superior. U.S. Fish Wildl. Serv., Fish. Bull. 63:493-530.

Samples from commercial landings at Duluth, Minn., in 1957-59 and at Bayfield, Wis., Portage Entry, Mich., and Marquette, Mich., in 1950-59 permitted comparisons among localities and study of trends in certain aspects of the life history of lake herring. Growth rate increased from west to east as did also the mean size of fish captured and the mean weight of fish at a given length. At Bayfield, Portage Entry, and Marquette, growth was faster and fish were heavier, length for length, in 1956-59 than in 1950-55. Annual fluctuations of growth rate were similar at the three ports. Age-group IV was dominant in all samples. Strength of year classes 1946-55 varied widely but had a broad downward trend. Fluctuations of year classes were similar at Marquette and Bayfield but at both ports did not resemble fluctuations at Portage Entry. All lake herring older than the III group were mature. Females outnumbered males (68.5:31.5). Information is given also on egg production, spawning, seasonal distribution, and food.

DUDEN, WILLIAM R.
1933. Recent advances in the fishing industry. The Fisherman (Grand Haven, Mich.) 2(10):3-4, 10-11; 2(12):3-4, 10.

Summary of developments in processing, transportation, marketing, advertising, and the utilization of byproducts.

DUDEN, WILLIAM R., vide: RALPH HILE.

EBEL, WESLEY J.
1962. A photoelectric amplifier as a dye detector. Great Lakes Fish. Comm., Tech. Rep. 4:19-26.

Describes a detector designed to record automatically the arrival of fluorescent dye at predetermined points on a stream. The instrument operates

efficiently in both clear and turbid water. It has saved time and costs in treatment of streams with chemicals to destroy larval sea lampreys.

EBEL, WESLEY J., vide: ROBERT A. BRAEM.

EDSALL, THOMAS A.
1960. Age and growth of the whitefish, Coregonus clupeaformis, of Munising Bay, Lake Superior. Trans. Amer. Fish. Soc. 89(4):323-332.

Life-history study of a dwarf whitefish stock confined to Munising Bay. Includes data on body-scale relation, growth rate, age composition, length-weight relation, sex ratio, and maturity. Growth was slowest reported for any Great Lakes stock. The fish required almost 8 years to reach 10 inches and 13 years to reach 15 inches. The weight of 1 pound was attained in 14 years. Maturity was attained at a small size but at an advanced age. All males were mature beyond 14.4 inches (age-group XII) and all females beyond 14.9 inches (age-group XII).

EDSALL, THOMAS A.
1964. Feeding by three species of fishes on the eggs of spawning alewives. Copeia 1964 (1):226-227.

Collections of alewives and of fish attendant on them during spawning demonstrated predation on alewife eggs as follows: 20 of 40 alewives (including both mature and immature fish); 37 of 43 spottail shiners; 1 of 2 emerald shiners. Scales (probably from shiners) had been ingested by the following numbers of fish: alewives, 33; spottail shiners, 18; emerald shiner, 1.

ELLIOTT, OLIVER R., vide: A. E. HALL; BERNARD R. SMITH.

EL-ZARKA, SALAH EL-DIN.
1959. Fluctuations in the population of yellow perch, Perca flavescens (Mitchill), in Saginaw Bay, Lake Huron. U.S. Fish Wildl. Serv., Fish. Bull. 59: 365-415.

Comparison of stock as to size, age, growth, length-weight relation, and sex ratio as shown by 1945-55 collections, and in an earlier study based on 1929-30 collections. Size and growth rate were low (slowest growth reported for the Great Lakes) in the more recent samples, but perch of a size to be taken in commercial trap nets were about seven times as numerous in 1945-55 as in 1929-30. The length-weight relations were similar in the two periods; males were relatively the more numerous in the more recent samples. Attempts to correlate year-class strength and annual fluctuations in growth met limited success. Year-class strength was not correlated with the abundance of legal-sized fish in year of origin or with temperature, precipitation, water level, or turbidity. First-year growth was correlated negatively with turbidity but not with year-class strength or other factors. Growth beyond the first year varied inversely with May to October water level but was not correlated with the abundance of legal-sized fish or other environmental factors.

ERKKILA, LEO F.
1962. Lamprey control and research in the United States. Great Lakes Fish. Comm., Annu. Rep. for 1962:25-39.

A summary report of work performed by the U.S. Bureau of Commercial Fisheries under contract with the Great Lakes Fishery Commission. Included is information on such matters as stream treatments for sea lamprey control, surveys of abundance and distribution, numbers of spawning lampreys taken in index weirs, biology of adult and larval lampreys, and research toward improving control methods and reducing costs. A sharp reduction of the abundance of lampreys in Lake Superior is stressed.

ERKKILA, LEO F.
1964. Lamprey control and research in the United States. Great Lakes Fish. Comm., Annu. Rep. for 1963:30-41.

A report corresponding to the one given by the same author for 1962. A major point is the continued reduction of spawning sea lampreys in Lake Superior--convincing evidence of the effectiveness of chemical control.

ERKKILA, LEO F., BERNARD R. SMITH, and ALBERTON L. McLAIN.
1956. Sea lamprey control on the Great Lakes, 1953 and 1954. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 175, ii + 27 p.

Summary of operations of electrical control devices in tributary streams along the south shore of Lake Superior and in northern Green Bay, Lake Michigan. Lists numbers of lampreys and fish taken in different streams and discusses the problem of minimizing the kill of useful species. Includes biological data on lamprey runs.

ERKKILA, LEO F., vide: PAUL H. ESCHMEYER.

ESCHMEYER, PAUL H.
1953. The effect of ether anesthesia on finclipping rate. Progr. Fish-Cult. 15(2): 80-82.

Comparisons of clipping rate for individual operators on alternate days when ether was and was not used indicated that anesthesia improved the number of lake trout fingerlings marked per hour by 75 to 100 fish or about 28 percent. Differences between anesthetized and unanesthetized fish with respect to quality of mark and postmarking mortality were small.

ESCHMEYER, PAUL H.
1955. The reproduction of lake trout in southern Lake Superior. Trans. Amer. Fish. Soc. 84:47-74.

Presents data on: spawning seasons and grounds; size at maturity; sex ratio and size distribution of spawning fish; "homing" instinct of local stocks; fecundity of "lean" lake trout and of siscowets; and relative accuracy of three methods of estimating the numbers of eggs in ovaries.

ESCHMEYER, PAUL H.
1956. The early life history of the lake trout in Lake Superior. Mich. Dep. Conserv., Inst. Fish. Res., Misc. Publ. 10, 31 p.

Materials collected by trawls and experimental gill nets yielded information on various phases of the life history during the first 3 years of life. Includes data on: abundance; bathymetric distribution and seasonal movements; progress of season's growth; annual increments; local differences of growth; sex ratio; food habits according to size of fish; and associated species of fish.

ESCHMEYER, PAUL H.
1957a. Note on the subpopulations of lake trout in the Great Lakes. In John C. Marr (coordinator), Contributions to the study of subpopulations of fishes, p. 129. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 208.

A brief statement of evidence of the existence of subpopulations of lake trout in the Great Lakes. This problem has received little study, and opportunities for investigation have disappeared or are dwindling rapidly because of the destruction of lake trout stocks by the sea lamprey.

ESCHMEYER, PAUL H.
1957b. The lake trout (Salvelinus namaycush). U.S. Fish Wildl. Serv., Fish. Leafl. 441, 11 p.

Popular account including a description of the fish and information on distribution, habitat, reproduction, age and growth, food, movements, and importance in the commercial and sport fisheries. The problem of destruction of lake trout stocks by the sea lamprey is reviewed briefly.

ESCHMEYER, PAUL H.
1957c. The near extinction of lake trout in Lake Michigan. Trans. Amer. Fish. Soc. 85:102-119.

Following the collapse of the commercial fishery for lake trout in Lake Michigan in the late 1940's, the further decline of the trout stocks was traced from records of small fish caught in small-mesh gill nets fished for chubs. By 1951, the abundance was only 4 percent of that prior to the sea lamprey invasion, and by 1955 the trout was near extinction--only eight fish were caught in 5-1/2 million linear feet of gill nets. Evidence is given that legal-sized (1-1/2 pounds and larger) and small trout declined at similar rates and that lampreys, not commercial fishing, were responsible for that decline.

ESCHMEYER, PAUL H.
1959. Survival and retention of tags, and growth of tagged lake trout in a rearing pond. Progr. Fish-Cult. 21(1):17-21.

Survival and retention of Petersen, cheek, and lower-jaw tags by 2-summer-old fish (86, 85, and 91 percent) were not significantly below survival of lake trout that had had the adipose fin excised (96 percent). All upper-jaw tags and 80.5 percent of the streamer tags were lost in 7 months; 99.5 percent of the streamer tags were lost in 1 year. Tags reduced growth in length about 25 percent. Because the upper-jaw and streamer tags which were lost in ponds had given good results on larger native lake trout in Lake Superior (details given) it was concluded that experiments with small fish in ponds do not provide a basis for prediction of the usefulness of a tag on fish in the Lake.

ESCHMEYER, PAUL H.
1964. The lake trout (Salvelinus namaycush). U.S. Fish Wildl. Serv., Fish. Leafl. 555, 8 p.

This latest revision of a leaflet of long standing includes information on morphology, distribution, spawning, fecundity, age, growth, artificial propagation, and the sport and commercial fisheries. Effects of the sea lamprey on Great Lakes stocks of lake trout are reviewed in the final section.

ESCHMEYER, PAUL H., and REEVE M. BAILEY.
1955. The pygmy whitefish, Coregonus coulteri, in Lake Superior. Trans. Amer. Fish. Soc. 84:161-199.

Discovery of a large population of pygmy whitefish in Lake Superior extended the known range by 1,100 miles. The morphology of the Lake Superior stock is compared with that of other populations. Information is given for the Lake Superior stock with respect to: geographic distribution and local abundance; bathymetric distribution; length frequencies; age and growth; sex ratio; maturity; fecundity; spawning; food; and associates.

ESCHMEYER, PAUL H., and WALTER R. CROWE.
1955. The movement and recovery of tagged walleyes in Michigan, 1929-1953. Mich. Dep. Conserv., Inst. Fish. Res., Misc. Publ. 8, 32 p.

Report on recaptures from 14,000 walleyes tagged in various State of Michigan waters over a 25-year period. Kind and extent of movements varied according to the conditions of the experiments. Walleyes tagged in the Muskegon River scattered widely through Lake Michigan; many were recovered 100-175 miles from the point of tagging. Tags depressed the rate of growth.

ESCHMEYER, PAUL H., RUSSELL DALY, and LEO F. ERKKILA.
1953. Movement of tagged lake trout in Lake Superior, 1950-1952. The Fisherman (Grand Haven, Mich.) 21(3):4, 11.

Condensed version of 1953 paper of the same authors under a similar title.

ESCHMEYER, PAUL H., RUSSELL DALY, and LEO F. ERKKILA.
1953. The movement of tagged lake trout in Lake Superior, 1950-1952. Trans. Amer. Fish. Soc. 82:68-77.

Recoveries from 733 native lake trout tagged at Cornucopia, Wis., and off the Keweenaw Peninsula amounted to 155 fish or 21.1 percent. Percentages of recapture for different kinds of tags were: aluminum, lower jaw, 10.7; monel, upper jaw, 14.0; streamer, 19.8; Petersen, 45.4. Large fish moved greater distances before recapture than did small ones. Many fish crossed State lines, and a few were captured in Canadian waters.

ESCHMEYER, PAUL H., vide: RALPH HILE; JOHN VAN OOSTEN.

FINLEY, W. L., vide: JOHN VAN OOSTEN.

GALLAGHER, HUBERT R., A. G. HUNTSMAN, D. J. TAYLOR, and JOHN VAN OOSTEN.
1943. Report of the International Board of Inquiry for the Great Lakes Fisheries. Int. Bd. Inq. Great Lakes Fish., Rep. Suppl.:1-24.

General review of management and research problems concluding with recommendations for: common investigation of the fisheries; joint regulation and management of stocks found to be common; provisions for collection of complete and accurate statistics; and tests of effectiveness of planting fish.

GALLAGHER, HUBERT R., and JOHN VAN OOSTEN.
1943. Supplemental report of the United States members of the International Board of Inquiry for the Great Lakes Fisheries. Int. Bd. Inq. Great Lakes Fish., Rep. Suppl.:25-213.

A major source of information on the Great Lakes fisheries. Body of report includes detailed treatment of: trends of production; evidence of and factors contributing to depletion; problems of regulation and management; history of the many unsuccessful attempts to attain adequate and uniform regulations; and need for international investigation and control. Appendixes include selected bibliography on the Great Lakes fisheries and complete record of all available statistics on production through 1940 (many of these statistics compiled from original records and published for the first time).

GORDON, WILLIAM G.
1961. Food of the American smelt in Saginaw Bay, Lake Huron. Trans. Amer. Fish. Soc. 90(4):439-443.

Young of the year (0 group) subsisted principally on planktonic Crustacea (copepods, cladocerans) which were present in all stomachs that contained food (no volume measurements). Fish in a Nov. 1 collection of the I-group

and older smelt from relatively deep water had consumed Mysis almost exclusively, but these larger fish captured from July 31 through Oct. 31 had a varied diet. Insects (principally Hexagenia) made up 46 to 63 percent of the food volume. Crustaceans (predominantly cladocerans and copepods) contributed 4 to 37 percent. The volume percentages for fish were nil to 49; the only forms identified were young smelt and Notropis.

GRAHAM, E. S., vide: S. L. DANIELS.

GROSSLEIN, MARVIN D., and LLOYD L. SMITH, JR.
1959. The goldeye, Amphiodon alosoides (Rafinesque), in the commercial fishery of the Red Lakes, Minnesota. U.S. Fish Wildl. Serv., Fish. Bull. 60:33-41.

The validity of age determinations from scales is proven, and a body-scale regression is set up for the calculation of growth from scale measurements. Males and females have equal growth to the end of 3 years of life when both average just over 11 inches; then the females grow the faster. In 6 years males averaged 13.6 and females 14.6 inches. The substantial annual fluctuations of growth are correlated positively with summer air temperature. A recent sharp decline of abundance has been correlated with increased fishing pressure (directed primarily at walleyes and yellow perch). The paper includes data on the length-weight relation and sex ratio.

HALL, A. E., JR., and OLIVER R. ELLIOTT.
1954. Relationship of length of fish to incidence of sea lamprey scars on white suckers, Catostomus commersoni, in Lake Huron. Copeia 1954(1):73-74.

Percentages of white suckers with lamprey scars at various lengths were: 5.0-10.9 inches, 11.0; 11.0-14.9 inches, 40.1; 15.0-20.9 inches, 70.6 percent. Incidence of multiple scars also increased with length of fish. These relations are attributed to: mechanical difficulty of lamprey attachment to the smaller fish; greater ability of the larger fish to survive attack; and greater length of time larger fish have been exposed to attack.

HALL, ALBERT E., JR., vide: VERNON C. APPLEGATE; HOWARD A. LOEB.

HANSON, LEE H., vide: JOHN H. HOWELL.

HARRIS, VIRGIL E., vide: VERNON C. APPLEGATE.

HIGGINS, ELMER.
1928a. Conference of Lake Erie biologists. Science 67(1734):309-310.

Report on meeting at Cleveland on February 6, 1928, of representatives of Federal, State, and Provincial research agencies and of scientific and educational institutions to formulate and coordinate plans for limnological and fishery investigations of Lake Erie.

HIGGINS, ELMER.
1928b. Cooperative fishery investigations in Lake Erie. Sci. Mon. 27(4):301-306.

General discussion of problems and goals of fishery research and an outline of cooperative researches on Lake Erie under the three general divisions: analysis of statistics of yield in relation to fishing intensity; life-history studies (age, growth, mortality, migration, food. . . .) of important species; and limnological and ecological inquiries with special reference to pollution problems.

HIGGINS, ELMER.
1929. Can the Great Lakes fisheries be saved? Outdoor Amer. 7(8):34-35.

Comments on the unique value and importance of the Great Lakes fisheries, explanation of decreasing productivity as the result of overfishing, and statement that adequate and uniform regulations are needed to conserve and restore the stocks.

HIGGINS, ELMER.
1938a. Fish outlive officials. State Govt. 11(3):53-54, 58.

Summary of arguments in support of belief that overfishing caused depletion of Great Lakes fisheries, review of past failures to attain adequate regulations through voluntary cooperation of State and Provincial agencies, and recommendation for establishment of central control by means of international treaty.

HIGGINS, ELMER.
1938b. The ineffectiveness of regulation of the Great Lakes fisheries by the individual states. Proc. Great Lakes Fish. Conf., Detroit, Mich., Feb. 25-26, 1938, Counc. State Govt., p. 48-60.

Review of bacteriological and limnological studies refuting contention that pollution has been a significant factor in the decline of Great Lakes fisheries, outline of evidence that overfishing has been the major cause, and comments on the impossibility of adequate regulation under divided control by the individual States.

HILE, RALPH.
1932. Fish scales and commercial fisheries. The Fisherman (Grand Haven, Mich.) 1(10):3-4, 10.

Description of methods of determining age and growth from scales and examples of application to fishery problems.

HILE, RALPH.
1934. Causes of variation in the growth rates of fishes. The Fisherman (Grand Haven, Mich.) 3(2):3-4, 10-11.

Discussion of growth types and of major factors responsible for growth differences in different populations and for fluctuations in growth within a single stock.

HILE, RALPH.
1935. Daily reports reveal new facts and figures. The Fisherman (Grand Haven, Mich.) 4(12):1-2.

Description of relation between fishing time and catch of fish in various types of stationary gear. Suggests that increase of catch with increase of nights out is so small that frequent lifting will give most efficient use of gear.

HILE, RALPH.
1936a. Age and growth of the cisco, Leucichthys artedi (Le Sueur), in the lakes of the northeastern highlands, Wisconsin. U.S. Bur. Fish., Bull. 48: 211-317.

Comparison of four populations as to growth rate, condition, sex ratio . . . in relation to such factors as population density, abundance of plankton, and physical-chemical conditions in lakes. In order of arrangement growth rate was correlated negatively with population density and concentration of bound CO_2, and condition was correlated negatively with the abundance of plankton. Differences among stocks as to length of growing season contributed to differences of growth rate. The relative abundance of females was greater in slow-growing than in fast-growing stocks and increased with age.

HILE, RALPH.
1936b. Age determination of fish from scales; method and application to fish cultural problems. Progr. Fish-Cult. Memo. I-131, No. 23:1-5.

Description of methods in age-and-growth studies. Comments on usefulness of growth data in management of waters, with special reference to planting programs.

HILE, RALPH.
1936c. Low production may not mean depletion. The Fisherman (Grand Haven, Mich.) 5(2):1-2.

Demonstration, from comparison of annual fluctuations of total yield and of catch per net, of danger of estimating abundance from production statistics.

HILE, RALPH.
1936d. Summary of investigations on the morphometry of the cisco, Leucichthys artedi (Le Sueur), in the lakes of the northeastern highlands, Wisconsin. Pap. Mich. Acad. Sci. Arts Lett. 21: 619-634.

Summary of research reported in full in 1937 paper.

HILE, RALPH.
1937a. Morphometry of the cisco, Leucichthys artedi (Le Sueur), in the lakes of the northeastern highlands, Wisconsin. Int. Rev. ges. Hydrobiol. Hydrogr. 36 (1/2): 57-130.

Comparison of morphological characteristics of four stocks of widely differing growth rates. Present elaborate division of artedi into subspecies is held to be without demonstrated validity by reason of: negative correlation, both between and within stocks, between growth rate and eye diameter, and length of head, maxillary, paired fins, and dorsal fin; progressive change of body proportions with increase in length; and existence of significant differences between year classes of same stock in both proportions and numerical characters.

HILE, RALPH.
1937b. The increase in the abundance of the yellow pike-perch, Stizostedion vitreum (Mitchill), in Lakes Huron and Michigan, in relation to the artificial propagation of the species. Trans. Amer. Fish. Soc. 66:143-159.

Comparison of plantings of yellow pikeperch (walleyes) with later production and abundance (on catch-per-net basis) to estimate value of artificial propagation. No evidence of benefits was found.

HILE, RALPH.
1941. Age and growth of the rock bass, Ambloplites rupestris (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wis. Acad. Sci. Arts Lett. 33:189-337.

Study of fluctuations in growth and strength of year classes of rock bass in a 95-acre landlocked Lake. Growth was correlated positively with temperatures in June and September (initial and terminal months of the growing season) and with precipitation in June. The strength of year classes was correlated positively with temperature and precipitation in May, June, and July. Other topics treated include: criteria for testing validity of annulus as a year-mark; sex and age differences in progress of season's growth; growth compensation as a real and as an "apparent" phenomenon; relation of growth rate to size and age at maturity; annual and seasonal fluctuations in the length-weight relation; and sex ratio.

HILE, RALPH.
1942. Growth of the rock bass, Ambloplites rupestris (Rafinesque), in five lakes of northeastern Wisconsin. Trans. Amer. Fish. Soc. 71:131-143.

Comparison of growth and length-weight relation in different populations. Growth curves of rock bass from lakes with medium-hard to hard water were more distinctly sigmoid and had larger increments in later years of life than curves for stock from soft-water lakes. Order of the stocks with respect to relative heaviness followed the order of the lakes as to hardness of water.

HILE, RALPH.
1943. Mathematical relationship between the length and the age of the rock bass, Ambloplites rupestris (Rafinesque). Pap. Mich. Acad. Sci. Arts Lett. 28:331-341.

Derivation of equation on the assumption that annual percentage growth in length decreases at a constant percentage rate, and application to growth of two stocks of rock bass. Equation, $L = K\ (CB + 1)\ (CB^2 + 1)\ (CB^3 + 1) \ldots (CB^t + 1)$, where L = length, t = age in years, and K, C, and B = constants, fitted growth of one stock through 9 years of life; in another the equation fitted over 6 years but yielded values that were too high for the seventh, eighth, and ninth years.

HILE, RALPH.
1948. Standardization of methods of expressing lengths and weights of fish. Trans. Amer. Fish. Soc. 75:157-164.

Recommendation for uniform use of total length (tip of head, mouth closed, to tip of tail, lobes compressed) and for English units of weight and measurement (with decimal fractions) in all but highly technical papers.

HILE, RALPH.
1949. Trends in the lake trout fishery of Lake Huron through 1946. Trans. Amer. Fish. Soc. 76:121-147.

Review of available statistics on production, 1879-1946, and detailed treatment of annual fluctuations in production, abundance, and fishing intensity in local districts of the U.S. waters, 1929-46, with special reference to the decline that followed the invasion and spread of the sea lamprey.

HILE, RALPH.
1950a. A nomograph for the computation of the growth of fish from scale measurements. Trans. Amer. Fish. Soc. 78:156-162.

Description of a device usable for rapid nomographic computation of growth from scale measurements regardless of the nature of the body-scale relation.

HILE, RALPH.
1950b. Green Bay walleyes. A report on the scientific investigation of the marked increase in abundance of walleyes in Green Bay. The Fisherman (Grand Haven, Mich.) 18(3):5-6.

Popular discussion pointing out: that the abnormally high abundance could be traced almost entirely to a single year class (1943); that a return to a much lower level could be considered inevitable; and that restrictive regulations intended to perpetuate the abnormal abundance would prove disappointing and would place unnecessary handicaps on the fishing industry.

HILE, RALPH.
1952a. Changes in the lake trout fishery in the three upper lakes. The Fisherman (Grand Haven, Mich.) 20(6):5, 8.

Comparison of production by State and Province in Lakes Michigan, Huron, and Superior in 1949 and 1950. Gives details for these two years on production, fishing intensity, and abundance of lake trout in the six statistical districts of the State of Michigan waters of Lake Superior. Records of catch per unit effort of gill nets, pound nets, and set-hooks indicated that use of nylon gill nets had not yet biased statistics seriously in 1950.

HILE, RALPH.
1952b. Fishing regulations. The Fisherman (Grand Haven, Mich.) 20(3):5, 12, 14.

Address to fishermen's associations of Michigan and Wisconsin suggesting possibility of control of fishing intensity through limitation of number of licenses as substitute for the "legally imposed inefficiency" of certain restrictive measures and calling for scientific inquiry into soundness of assumptions as to proper size limits, closed seasons . . . on which current regulations are based.

HILE, RALPH.
1952c. 25 years of Federal fishery research on the Great Lakes. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 85, i + 48 p.

The original article of which the present one is a second revision and expansion.

HILE, RALPH.
1953a. Perch studies in Green Bay. Progr. Fish-Cult. 15(3):133-134.

The studies were started cooperatively by the Fish and Wildlife Service and the Wisconsin Conservation Department in 1948 to learn causes of poor fishing and to obtain a better basis for management. Evidence that growth was so slow that few fish survived to reach the minimum legal length of 8 inches led to a lowering of the limit to 7-1/2 inches in 1952. During the 1952 season fishermen kept 250 fish for every 100 they could have retained under the former limit. No effects could be detected on the yellow perch population.

HILE, RALPH.
1953b. Trout fishing in Michigan waters of Lake Superior, 1952. The Fisherman (Grand Haven, Mich.) 21(5):7, 11-12, 14.

Description of trends of production, fishing intensity, and abundance in the six statistical districts of State of Michigan waters, 1949 through 1952. Analyses of catch per unit effort after general change from cotton to nylon gill nets led to suggestion that gill nets draw on a different segment of the population than that exploited by pound nets and set-hooks.

HILE, RALPH.
1954a. Changing concepts in fishery research on the Great Lakes. Proc. Gulf Carib. Fish. Inst., 6th Annu. Sess.: 64-70.

The approach in earlier research was biased by undue emphasis on depletion through overfishing as the major, perhaps the only significant factor in the progressive deterioration of the Great Lakes fisheries. Too little attention was given to effects of selective fishing, species interactions, and environmental changes. It is now realized that populations should be studied as a whole, all species together in relation to their changing environment. In this complex situation, application of modern fishing theory offers little promise of profitable return.

HILE, RALPH.
1954b. Fluctuations in growth and year-class strength of the walleye in Saginaw Bay. Fish Wildl. Serv., Fish. Bull. 56:7-59.

Collections of 1926-30 yielded information on the relative strength of year classes in 1917-28 and on fluctuations of growth in length and weight in 1916-29. A single collection of 1943 provided some information on these matters for later years and demonstrated a large increase of growth rate and decrease of average age after 1929. Paper includes data on commercial production, length-weight relation, sex ratio, and size at maturity.

HILE, RALPH.
1954c. Status and future of the American Fisheries Society. Trans. Amer. Fish. Soc. 83:357-359.

Presidential address at eighty-third annual meeting urging: a more democratic organization; the wielding of greater influence in fishery matters of general public concern; and the ending of the trend toward superficiality in research.

HILE, RALPH.
1955. The walleye problem in Green Bay. Progr. Fish-Cult. 17(1):44.

Review of the consequences of the phenomenal strength of the 1943 year class--enormous increases of production and fishing pressure, frictions among groups of commercial operators and between commercial and sport fishermen, and use of scientific information on walleyes in preventing passage of unwise restrictive legislation.

HILE, RALPH.
1957. U.S. Federal fishery research on the Great Lakes through 1956. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 226, iii + 46 p.

Second of the series in which the present report is the third.

HILE, RALPH.
1962. Collection and analysis of commercial fishery statistics in the Great Lakes. Great Lakes Fish. Comm., Tech. Rep. 5, ii + 31 p.

The development of the reporting system and of methods of analysis is reviewed, and analytical procedures are illustrated by example. Particular attention is given to the basis for charging a species only with fishing that produces the species (effective fishing effort) and to the reduction of fishing effort for different gears to an "expected catch" in pounds. Exceptions to standard procedure and special problems of analysis and interpretation are explained.

HILE, RALPH, and HOWARD J. BUETTNER.
1955. Commercial fishery for chubs (ciscoes) in Lake Michigan through 1953. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 163, ii + 49 p.

Historical review of a fishery based on seven deep-water species of coregonids. Includes the fragmentary and scattered statistics of 1890-1925, the continuous and more dependable catch statistics of 1926-54, and data on catch, fishing intensity, and abundance in local areas for Michigan (1929-54), Wisconsin (1953-54), and Illinois (1950-54). Discusses: biasing effects of changes in fishing laws and of types of gill net twine (linen, cotton, nylon) on estimation of abundance; and comments on deterioration of the fishery resulting from the end of lake trout predation on small chubs, the attacks of sea lampreys on large chubs, and the large increase in fishing intensity. Data for 1954 in an appendix.

HILE, RALPH, and HOWARD J. BUETTNER.
1959. Fluctuations in the commercial fisheries of Saginaw Bay, 1885-1956. U.S. Fish Wildl. Serv., Res. Rep. 51, iv + 38 p.

In addition to production data for 1885-1956, includes statistics on fishing intensity and abundance for principal species in 1929-56. By 1956, lake trout, whitefish, walleyes, and lake herring were scarce, but the abundance was well above average for yellow perch, suckers, carp, and catfish. The role of the sea lamprey in the decline of lake trout, whitefish, and walleyes is discussed. Loss of these high-priced species has placed the fishery in an economically precarious situation. Fishing intensity and production are falling off.

HILE, RALPH, and HILARY J. DEASON.
1934. Growth of the whitefish, Coregonus clupeaformis (Mitchill), in Trout Lake, northeastern highlands, Wisconsin. Trans. Amer. Fish. Soc. 64:231-237.

Description of growth of a "dwarf" population of whitefish and a comparison with growth in other waters.

HILE, RALPH, and HILARY J. DEASON.
1947. Distribution, abundance, and spawning season and grounds of the kiyi, Leucichthys kiyi Koelz, in Lake Michigan. Trans. Amer. Fish. Soc. 74:143-165.

Analysis of catch data from experimental gill nets for records of geographic distribution and study of vertical distribution and regional abundance. Kiyi established as deep-water form taken in numbers in less than 50 fathoms only at times of unusual hydrographic disturbances. Abundance determined to be nearly uniform throughout great central basins, but species was scarce in northeastern island area. Spawning-run samples indicated no movement toward inshore waters and a spawning season extending from late September to mid-November or later.

HILE, RALPH, and WILLIAM R. DUDEN.
1933. Methods for the investigation of the statistics of the commercial fisheries

of the Great Lakes. Trans. Amer. Fish. Soc. 63:292-305.

Account of tentative procedures for compilation and analysis of commercial fishery statistics. Includes a definition of "effective fishing effort" for use in fisheries based on a variety of species.

HILE, RALPH, PAUL H. ESCHMEYER, and GEORGE F. LUNGER.
1951a. Decline of the lake trout fishery in Lake Michigan. Fish Wildl. Serv., Fish. Bull. 52:77-95.

Statistical study of the lake trout fishery similar to that made by Hile (1949) for Lake Huron. Detailed records of fishing pressure in 1929-49 proved that overfishing could not have been a significant factor in decline of lake trout in State of Michigan waters of Lake Michigan and contributed to conclusion that sea lamprey depredations offered the only reasonable explanation.

HILE, RALPH, PAUL H. ESCHMEYER, and GEORGE F. LUNGER.
1951b. Decline of the trout fishery in Lake Michigan. The Fisherman (Grand Haven, Mich.) 19(1):5, 10.

Summary of longer paper published by same authors under similar title in same year.

HILE, RALPH, PAUL H. ESCHMEYER, and GEORGE F. LUNGER.
1951c. Status of the lake trout fishery in Lake Superior. Trans. Amer. Fish. Soc. 80:278-312.

Review similar to that in other 1951 article by same authors for Lake Michigan. No evidence existed of injury to lake trout in Lake Superior by sea lamprey through 1949. Stocks were nevertheless in precarious condition as result of long-term trends which had led to excessively higher fishing pressures and abnormally low availability in State of Michigan waters (and probably in other regions of Lake) by that year.

HILE, RALPH, PAUL H. ESCHMEYER, and GEORGE F. LUNGER.
1951d. Status of the lake trout fishery in Lake Superior. The Fisherman (Grand Haven, Mich.) 19(3):5, 13.

Summary of longer paper published by same authors under same title in same year.

HILE, RALPH, and FRANK W. JOBES.
1941a. Age and growth of the yellow perch, Perca flavescens (Mitchill), in the Wisconsin waters of Green Bay and northern Lake Michigan. Pap. Mich. Acad. Sci. Arts Lett. 27:241-266.

Investigation of such phases of the life history as age and size, growth in length and weight, length-weight relation, sex ratio, and maturity, and a comparison indicating growth rates to be similar in southern Green Bay and northwestern Lake Michigan proper, but much slower in both areas than in Saginaw Bay and Lake Erie.

HILE, RALPH, and FRANK W. JOBES.
1941b. Age, growth, and production of the yellow perch, Perca flavescens (Mitchill), of Saginaw Bay. Trans. Amer. Fish. Soc. 70:102-122.

Analysis of production records, 1891-1938, and of annual fluctuations in abundance and fishing intensity, 1929-38, and life-history study with data on body-scale relation, age and size, growth, length-weight relation, and sex ratio.

HILE, RALPH, and CHANCEY JUDAY.
1941. Bathymetric distribution of fish in lakes of the northeastern highlands, Wisconsin. Trans. Wis. Acad. Sci. Arts Lett. 33:147-187.

Comparison of bathymetric distribution of fish in four lakes, revealing a wide variation from one water to another and, except for the cisco, a lack of clear-cut dependence of that variation on such factors as temperature and concentrations of dissolved oxygen and free carbon dioxide.

HILE, RALPH, GEORGE F. LUNGER, and HOWARD J. BUETTNER.
1953. Fluctuations in the fisheries of State of Michigan waters of Green Bay. Fish Wildl. Serv., Fish. Bull. 54:1-34.

Comparison of production levels and trends in 1885, 1891-1908, and 1929-49, and description of relations of fluctuations in production, abundance, and fishing intensity in last period. Questions soundness of interpreting decline in mean annual take of all species from 7 million pounds in 1891-1908 to 3-1/2 million pounds in 1929-49 as result of overfishing; the relatively cheap lake herring alone more than accounted for the decrease while the average annual take of more prized varieties increased

(for example, annual yield of the valuable whitefish in 1929-49 was 4-1/2 times that in 1891-1908). Concludes with discussion of the problem of regulation.

HILE, RALPH, vide: HILARY J. DEASON; LOUIS A. KRUMHOLZ; STANFORD H. SMITH; JOHN VAN OOSTEN.

HOOPER, FRANK, vide: ALFRED M. BEETON.

HOWELL, JOHN H., EVERETT L. KING, ALLEN J. SMITH, and LEE H. HANSON.
1964. Synergism of 5,2'-dichloro-4'-nitrophenol in a selective lamprey larvicide. Great Lakes Fish. Comm., Tech. Rep. 8:1-21.

A mixture of 98 percent TFM and 2 percent Bayluscide has a strongly synergistic effect which reduces the amount and cost of chemicals in treatments of streams for the selective destruction of the sea lamprey. Synergistic effects are reduced at lesser percentages of Bayluscide, and selectivity is impaired at percentages above 3.

HOWELL, JOHN H., and WILLMAN M. MARQUETTE.
1962. Use of mobile bioassay equipment in the chemical control of sea lamprey. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 418, iv + 9 p.

Describes bioassay facilities installed in an 18-foot house-trailer shell. This mobile laboratory permits rapid, accurate streamside tests that must precede each application of a selective toxicant for destruction of larval sea lampreys. Test procedures are described, and examples are given of data obtained and of interpretation of bioassay records.

HOWELL, JOHN H., and PAUL M. THOMAS.
1964. Anesthetic effect of 4-styrylpyridine on lamprey and fish. Trans. Amer. Fish. Soc. 93(2):206-208.

The anesthetic property of 4-styrylpyridine (4-SP) was first detected when the compound was tested in a screening program seeking chemicals that were selectively toxic to sea lampreys. More detailed experiments on different species and stages of lampreys and on five bony fishes revealed anesthetic action similar to that determined at higher concentrations of other anesthetics. The compound can be handled safely by humans.

HOWELL, JOHN H., vide: VERNON C. APPLEGATE.

HUNTSMAN, A.G., vide: HUBERT R. GALLAGHER.

JACOBY, CARL.
1961. Relative growth of fins in the fourhorn sculpin, Myoxocephalus quadricornis, from the upper Great Lakes. Copeia 1961(4):473-475.

The relative lengths of all fins but the caudal increased with length of the fish. Relative growth of fins of immature sculpins and of mature females proceeded along the same uninflected logarithmic lines, but growth lines for fins of males were inflected at the length of attainment of maturity (roughly 40 mm., standard length). Growth constants of fins of mature males ranged from 1.17 (pectoral) to 2.02 (second dorsal); for females and immature fish from 1.04 (pectoral) to 1.24 (first dorsal). Males invariably had the higher constants.

JOBES, FRANK W.
1932. Deep trapnets on Lakes Huron and Michigan. The Fisherman (Grand Haven, Mich.) 1(3):3-4.

An outline of the cooperative program (with the Michigan Department of Conservation) to study the effects of this new and unusually efficient net on stocks of whitefish.

JOBES, FRANK W.
1933. Preliminary report on the age and growth of the yellow perch (Perca flavescens Mitchill) from Lake Erie, as determined from a study of its scales. Pap. Mich. Acad. Sci. Arts Lett. 17:643-652.

Brief report on analysis of first 2 years' collections in life-history study, including data on age composition (evidence of phenomenal strength of 1926 year class) and growth in length and weight.

JOBES, FRANK W.
1943. The age, growth, and bathymetric distribution of Reighard's chub, Leucichthys reighardi Koelz, in Lake Michigan. Trans. Amer. Fish. Soc. 72:108-135.

Life-history and distributional study based on 1930-32 collections by experimental gill nets. Reighard's chub spawned in May and June at 20-79 fathoms; in other months it was most

plentiful at 20-60 fathoms. Abundance on east shore of lower half of Lake was seven times that on west shore and three times that in northern part of Lake. Age-group IV (average length 10.9 inches; average weight 6.1 ounces) dominated samples. Females outnumbered males and survived to greater age.

JOBES, FRANK W.
1949a. The age, growth, and bathymetric distribution of the bloater, Leucichthys hoyi (Gill), in Lake Michigan. Pap. Mich. Acad. Sci. Arts Lett. 33:135-172.

Study of distribution from 1930-32 collections from experimental gill nets and of growth from earlier (1919 and 1928) collections from Grand Haven, Mich. Bloaters were most plentiful at 20-59 fathoms (the larger fish were in the deeper water in some months); abundance on the east shore of lower part of Lake was 1-1/2 times that on the west shore and 2-1/3 times that in the northern part of the Lake. Samples were dominated by age-group IV in 1919 and (weakly) by age-group II in 1928. Growth was slightly more rapid in females than in males but was slow in both sexes (barely 8 inches in 5 years). Females outnumbered males.

JOBES, FRANK W.
1949b. The age, growth, and distribution of the longjaw cisco, Leucichthys alpenae Koelz, in Lake Michigan. Trans. Amer. Fish. Soc. 76:215-247.

Study of the distribution from 1930-32 collections from experimental gill nets and of growth from earlier (1923 and 1928) collections. Longjaw was most plentiful at less than 70 fathoms and more than four times as abundant in the northern part of Lake and along the east shore as on the west shore of the lower Lake. Samples were dominated by age-groups III or IV. Growth was similar off Grand Haven, Mich., and in northeastern Lake Michigan (average length about 11 inches and average weight about 6-1/4 ounces at end of 4 years). Sex ratio was variable, but females generally outnumbered males and reached higher ages.

JOBES, FRANK W.
1952. Age, growth, and production of yellow perch in Lake Erie. Fish Wildl. Serv., Fish. Bull. 52:205-266.

Review of production statistics, 1885-1947, and detailed life-history study. Includes materials on validity of scale readings, body-scale relation, size and age distribution, growth (including annual fluctuations, length of growing season, and growth compensation), length-weight relation and condition (including fluctuations by month and year and according to age and sexual state), maturity, and sex ratio.

JOBES, FRANK W., vide: RALPH HILE; JOHN VAN OOSTEN.

JOERIS, LEONARD S.
1953. Technique for the application of a streamer-type fish tag. Trans. Amer. Fish. Soc. 82:42-47.

Principal features of the technique are: attachment of tag by a nylon-thread loop prepared in advance of field work; application of tag by means of a curved surgical needle with a cutting edge and a split eye. Preparation of needle and tagging procedure are described.

JOERIS, LEONARD S.
1957. Structure and growth of scales of yellow perch of Green Bay. Trans. Amer. Fish. Soc. 86:169-194.

Establishes the validity of the annulus as a year-mark in Green Bay yellow perch. Variations in time of annulus formation by calendar year, locality, and age are described in relation to the problem of age determination for fish caught early in the growing season. Body-scale regressions are given and compared for "key scales" from two positions on the fish.

JOERIS, LEONARD S.
1959. Rapid measurement of fish. Progr. Fish-Cult. 21(4):190-191.

Lengths of fish are recorded rapidly by punching holes with a needle (usually soldered to a thimble) on strips of used X-ray film from which the emulsion has been washed. In the laboratory, the strips are placed on a transparent ruler on a surface illuminated from below and points between graduations are counted. Advantages of the method are listed and procedures aboard vessels described.

JOERIS, LEONARD S.
1964. A horizontal sampler for collection of water samples near the bottom. Limnol. Oceanogr. 9(4):595-598.

The new sampler permits more effective study of water characteristics in a narrow stratum, particularly the

one immediately above the lake bottom. Details of construction and operation are described and illustrated.

JOERIS, LEONARD S., vide: WALTER R. CROWE.

JOHNSON, B.G.H., vide: VERNON C. APPLEGATE; MANNING A. SMITH.

JOHNSON, JAMES H.
1958. Surface-current studies of Saginaw Bay and Lake Huron, 1956. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 267, v + 84 p.

Of 2,650 drift bottles released in Saginaw Bay and lower Lake Huron, 1,843 (69.5 percent) were returned. These returns were the basis of description of currents in the Bay; bottle returns and dynamic-height calculations were used for the Lake proper. Wind direction was most important in movements of bottles in Saginaw Bay, but the correlation was less apparent in Lake Huron. Drift of bottles was generally west to east under the influence of prevailing winds.

JOHNSON, JAMES H.
1960. Surface currents in Lake Michigan, 1954 and 1955. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 338, viii + 120 p.

Drift bottles, drift envelopes, and plastic tubes were released in 1954; since bottles yielded best returns they alone were released in 1955. Currents were highly variable in both years and in all parts of the Lake. General drift was west to east. Currents were predominantly northbound along the east shore, but no prevailing current was detected along the west shore. Full details on individual recoveries are given in appendix.

JOHNSON, JAMES H., vide: ALFRED M. BEETON.

JONES, DAVID L., vide: CHARLES F. POWERS.

JUDAY, CHANCEY, vide: RALPH HILE.

KANAYAMA, RICHARD K.
1963. The use of alkalinity and conductivity measurements to estimate concentrations of 3-trifluormethyl-4-nitrophenol required for treating lamprey streams. Great Lakes Fish. Comm., Tech. Rep. 7, 10 p.

The relation of methyl-purple alkalinity and conductivity to the minimum lethal (lowest that destroys all sea lamprey larvae) and maximum allowable (highest that does not kill more than 25 percent of test fish) concentrations of 3-trifluormethyl-4-nitrophenol is sufficiently precise to permit the use of these water characteristics to estimate the range of concentrations over which bioassays should be made prior to a stream treatment. The estimates bring significant economies in time and use of equipment.

KARVELIS, ERNEST G.
1964. The true pikes. U.S. Fish Wildl. Serv., Fish. Leafl. 569, 11 p.

Popular account of five North American members of the genus Esox (muskellunge, northern pike, chain pickerel, grass pickerel, and redfin pickerel) includes morphological data and a key for the separation of species and subspecies. Information on natural history touches on distributions, habitat, spawning (including artificial propagation), feeding, age, and growth.

KARVELIS, ERNEST G., vide: WALTER R. CROWE.

KEMPE, L. L., STACY DANIELS, and ALFRED M. BEETON.
1962. Microorganic constituents of water of the Great Lakes. [Abstract.] In Proc. 5th Conf. Great Lakes Res., p. 172-173. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 9.

Organic materials were obtained from activated-carbon filters installed at the water intake of the Bureau of Commercial Fisheries Biological Station at Hammond Bay on Lake Huron and aboard the research vessel Cisco. Eluates are separated on basis of solubility in various solvents. Infrared and ultraviolet spectra give information on various fractions.

KEMPE, L. L., vide: S. L. DANIELS.

KING, EVERETT L., JR., vide: VERNON C. APPLEGATE; JOHN H. HOWELL.

KOELZ, WALTER N.
1921. Description of a new cisco from the Great Lakes. Univ. Mich., Mus. Zool., Occas. Pap. 104:1-4.

Original description of Leucichthys kiyi-type collected in Lake Michigan 12 miles E. by S. from Sturgeon Bay Ship Canal, August 23, 1920.

KOELZ, WALTER.
1924. Two new species of cisco from the Great Lakes. Univ. Mich., Mus. Zool., Occas. Pap. 146:1-8.

Original description of Leucichthys alpenae-type collected in Lake Michigan, 22 miles NNE. of Charlevoix, Mich., June 15, 1923--and of Leucichthys reighardi-type from Lake Michigan, 18 miles N. by W. of Michigan City, Ind., April 1, 1921.

KOELZ, WALTER.
1925. Description of a new cisco from the Great Lakes basin. Univ. Mich., Mus. Zool., Occas. Pap. 158:1-3.

Original description of Leucichthys nipigon-type collected from Lake Nipigon off MacDiarmid, July 28, 1922.

KOELZ, WALTER.
1926. Fishing industry of the Great Lakes. Rep. U.S. Comm. Fish. for 1925:553-617.

General account of the fisheries. Introductory section on boats, gear, organization, and products is followed by sections giving for individual Lakes: brief description of Lakes; history of development of fishery; fishing districts; description of fishery for individual species; and summary of regulations on gear, size limits, and closed seasons.

KOELZ, WALTER.
1928. Fisheries of the Great Lakes. General review. In Elmer Higgins, Progress in biological inquiries, 1926, p. 660-662. Rep. U.S. Comm. Fish. for 1927.

Brief comments on a variety of subjects, including: productivity of the different Lakes in pounds per square mile; importance of taxonomic study of coregonids, a group contributing half of the total Great Lakes catch; collapse of the Lake Erie cisco fishery; and evidences of general depletion and need for international regulation of the Great Lakes fisheries.

KOELZ, WALTER.
1929. Coregonid fishes of the Great Lakes. U.S. Bur. Fish., Bull. 43 (pt. 2):297-643.

Monographic taxonomic and natural history study of coregonids of Great Lakes and Lake Nipigon. Includes extensive data on morphological variation, geographical and bathymetric distribution, food, size, maturity, and spawning seasons and grounds. Discusses problem of origin and speciation in coregonids of the Great Lakes basin.

KOELZ, WALTER.
1931. The coregonid fishes of northeastern America. Pap. Mich. Acad. Sci. Arts Lett. 13:303-432.

Elaborate systematization of coregonids of the area. Divides Leucichthys artedi into 24 subspecies (17 described as new), Coregonus clupeaformis into 7 subspecies (4 new); and Prosopium quadrilaterale into 2 subspecies (1 new). Includes also original description of Leucichthys bartletti.

KRAMER, ROBERT H., vide: LLOYD L. SMITH, JR.

KREFTING, LAURITS W., vide: LLOYD L. SMITH, JR.

KRUMHOLZ, LOUIS A., and RALPH HILE.
1944. Fillet weights and loss in filleting of yellow pikeperch, Stizostedion v. vitreum (Mitchill), from Saginaw Bay, November 1942, May 1943, and April 1944. Mich. Dep. Conserv., Inst. Fish. Res., Rep. 973:1-5.

Review of series of filleting experiments that served as basis of present Michigan minimum legal weight of 9 ounces for walleye fillets.

LENNON, ROBERT E.
1954. Feeding mechanism of the sea lamprey and its effect on host fishes. Fish Wildl. Serv., Fish. Bull. 56:247-293.

Attachment to the fish and penetration of the fish's body by the sea lamprey are furthered by the suctorial, tooth-lined mouth and the rasping tongue. Feeding is assisted by secretions from the buccal glands, which are potent anticoagulants and have a marked hemolytic and cytolytic action. Most victims die of hemorrhage; the erythrocyte count of dying fish is reduced 84 percent. Survivors of lamprey attacks often die of fungus infection of the wound. Data are given on the relative frequency of wounds on different parts of the fish's body and the gross pathology is described for wounds in different locations.

LENNON, ROBERT E.
1955. Artificial propagation of the sea lamprey, Petromyzon marinus. Copeia 1955(3):235-236.

Account of the stripping, fertilization, hatching (10 to 16 days at 67°-71° F.), early development, growth, and behavior. Observations were concluded after 21 weeks.

LENNON, ROBERT E., vide: PHILLIP S. PARKER.

LOEB, HOWARD A.
1953. Sea lamprey spawning: Wisconsin and Minnesota streams of Lake Superior. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 97, iii + 36 p.

Report on the examination of all tributaries in Minnesota, part of the streams of Wisconsin, and the streams of Grand Island. Streams are classified as to their "lamprey potential" on the basis of spawning facilities, larval habitat, and presence of natural or manmade barriers to migration.

LOEB, HOWARD A., and ALBERT E. HALL, JR.
1952. Sea lamprey spawning: Michigan streams of Lake Superior. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 70, iii + 68 p.

Results of surveys of 869 streams in 1950 and 178 in 1951 (both figures inclusive of tributaries) to ascertain occurrence of sea lamprey spawning runs and to estimate productive potentials of streams on basis of extent of spawning grounds and larval habitat. Tentative outline is given of control program (based principally on electrical devices and barrier dams) for the 194 streams on which control ultimately may prove necessary.

LUNGER, GEORGE F., vide: RALPH HILE.

MACY, PAUL T., vide: VERNON C. APPLEGATE.

MAGNUSON, JOHN L., and LLOYD L. SMITH.
1963. Some phases of the life history of the trout-perch. Ecology 44(1):83-95.

Contains information on various phases of the life history, including body-scale relation, age and size composition, growth in length and weight, growth compensation, sex ratio, spawning, and fecundity. Annual fluctuations of growth were correlated positively with degree-days but not with population density. Year-class strength was correlated positively with degree-days and negatively with wind but not with reproductive capacity. Adult walleyes were the principal predators on the trout-perch.

MARQUETTE, WILLMAN M., vide: JOHN H. HOWELL.

MARSHALL, J. S., A. M. BEETON, and D. C. CHANDLER.
1964. Role of zooplankton in the freshwater strontium cycle and influence of dissolved salts. Proc. Int. Ass. Theor. Applied Limnol. 15(2):665-672.

Experiments were made with Daphnia magna to determine factors affecting the uptake of strontium. Around 95 percent of an animal's strontium is in the exoskeleton and is lost upon molting. Strontium accumulates in the organism due to active metabolic uptake of the element directly from water. The ratio Sr/Ca seems to remain constant, although it varies in the environment.

McLAIN, ALBERTON L.
1952. Diseases and parasites of the sea lamprey, Petromyzon marinus, in the Lake Huron basin. Trans. Amer. Fish. Soc. 81:94-100.

Results of examination of 215 recently transformed young, 29 active feeders from the Lake, and 257 sexually mature upstream migrants. Evidence of disease was small. Percentages of parasitic infestation were: recently transformed young--2.3; Lake feeders--31.0; sexually mature lampreys--14.8. Young lampreys harbored nematodes only; last two groups carried acanthocephalans, nematodes, and cestodes. Parasites are considered unimportant as a natural control of the lamprey.

McLAIN, ALBERTON L.
1957. The control of the upstream movement of fish with pulsated direct current. Trans. Amer. Fish. Soc. 86:269-284.

Alternating-current barriers placed in streams to block spawning runs of sea lampreys in some situations cause heavy mortalities of useful fish. To reduce this loss a direct-current diversion device is placed downstream. This equipment is described and the circuitry is illustrated. Most significant feature is the introduction of the negative field into the stream. Fish are

turned away from the alternating-current field and diverted into a trap. Two devices tested over an entire season gave excellent results.

McLAIN, ALBERTON L., and WILLIS L. NIELSEN.
1953. Directing the movement of fish with electricity. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 93, ii + 24 p.

Description of equipment, procedure, and results in laboratory and field experiments (mostly with brook trout, rainbow trout, and white suckers). Best results were obtained with square wave shape at a duty cycle of 0.66, frequency of 3/sec. Variation of reaction according to size of fish was a major difficulty. Technical problems are reviewed, and recommendations made for further research.

McLAIN, ALBERTON L., vide: VERNON C. APPLEGATE; LEO F. ERKKILA; BERNARD R. SMITH.

MERNA, JAMES W.
1962. Quantitative sampling with the orange-peel dredge. Limnol. Oceanogr. 7(3):432-433.

Under laboratory conditions, the surface area sampled increased with depth of penetration of the dredge from about 65 square inches, at a depth of 1 inch to about 138 square inches at 5 inches. Further increase of penetration to 6 inches did not increase the area. The relation between sampling area ($\underline{A}$) and volume of sample ($\underline{V}$) was described by the equation, $\underline{A} = 51.83 + 0.338\underline{V} - 0.000336\underline{V}^2$.

MOFFETT, JAMES W.
1950a. Progress report on the sea lamprey program. The Fisherman (Grand Haven, Mich.) 18(7):5, 8.

Outline of organization of the expanded Great Lakes Fishery Investigations, account of works in progress, and statement of proposed researches on the development of methods of controlling the sea lamprey.

MOFFETT, JAMES W.
1950b. Sea lamprey control. Mich. Conserv. 19(4):18-20.

Popular review of the subject emphasizing the use of known facts in the life history of the sea lamprey in the technical problem of developing methods of control by mechanical barriers, electricity, poisons, and other means.

MOFFETT, JAMES W.
1952. The study and interpretation of fish scales. Sci. Counselor 15(2):40-42.

Popular account touching such points as: structure of scales; development of the use of scales and bones for growth studies; preparation and microscopic examination of scales and scale impressions; and practical applications of growth data.

MOFFETT, JAMES W.
1953a. Lake fisheries need lamprey control and research. The Fisherman (Grand Haven, Mich.) 21(4):10-11, 14.

The invasion of the sea lamprey, its destruction of lake trout in Lakes Huron and Michigan, and its threat to Lake Superior are reviewed. Control of lampreys is imperative if fisheries are to be spared in Lake Superior and restored in Lakes Huron and Michigan. Yet, control is not enough. We must have greatly expanded and continuing research to learn the factors of abundance of fish. Certain specific research problems are listed.

MOFFETT, JAMES W.
1953b. Report of Committee on Hydrobiology and Fish Culture. Trans. Amer. Fish. Soc. 82:315-320.

Major impediments to effective research include: a poor "research climate," inherent in our very culture; superficiality of training; a mania for action programs which demand quick results and give no opportunity for mature consideration; and diversion of best researchers into administration. Suggestions are given for the correction of these evils.

MOFFETT, JAMES W.
1953c. War on lampreys. Philadelphia Enquirer, Aug. 23, p. 16-17.

Popular account of the invasion of the sea lamprey, its threat to the fisheries, and steps taken to meet that threat.

MOFFETT, JAMES W.
1954a. A research program for Lake Erie. The Fisherman (Grand Haven, Mich.) 22(1):7, 11-12, 14.

Detailed suggestions are offered for research along four major lines: identities, distribution, and movements of stocks; fluctuations of catch and availability in relation to year-class strength, size at capture, and rate of exploitation; factors of abundance; and experimental management.

MOFFETT, JAMES W.
1954b. Fisheries knowledge increased through research vessel. The Fisherman (Grand Haven, Mich.) 22(3):7, 13-14.

Description of the vessel Cisco, with: photograph, deck plans, and sectional sketch; listing of equipment and gear for navigation and for fishery, limnological, and hydrographic research; and discussions of types of research made possible by the vessel and of practical contributions to fishery knowledge and management.

MOFFETT, JAMES W.
1954c. Killers of the Great Lakes. The book of knowledge annual, 1954, p. 125-127.

Popular, illustrated story of the sea lamprey, its damage to the fishery, and research aimed at the development of effective control.

MOFFETT, JAMES W.
1955. Fisheries of the Great Lakes. In The Great Lakes and Michigan, p. 36-37. Univ. Mich., Great Lakes Res. Inst.

Includes brief comments on: the limits of research of earlier years; expansion of studies in the face of the sea lamprey crisis; present research program on the lamprey, and on limnology and fisheries; and the outlook for future research.

MOFFETT, JAMES W.
1956a. Great Lakes Fishery Commission: role of the Commission in the solution of fishery problems. In Great Lakes--programs and problems, p. 14-16. Great Lakes Fish. Comm.

Describes the origin and organization of the Commission; lists its principal duties as (1) the development and implementation of programs for research on and control of the sea lamprey and (2) coordination of fishery research on the Great Lakes; and reviews early activities of the Commission and its Scientific Advisory Committee.

MOFFETT, JAMES W.
1956b. Status of sea lamprey control. Wis. Conserv. Bull. 21(4):14-17.

Up-to-date statement of progress, extent, and methods of current control program; plans for expansion are outlined, and possible alternative use of chemicals is discussed.

MOFFETT, JAMES W.
1956c. The lake trout endangered in the Great Lakes. In Our endangered wildlife, p. 23-24. Nat. Wildl. Fed., Washington, D.C.

Review of effects of sea lamprey predation which has brought the lake trout to near extinction in Lakes Huron and Michigan and warning of impending collapse in Lake Superior if lamprey control is not achieved soon.

MOFFETT, JAMES W.
1957. Recent changes in the deep-water fish populations of Lake Michigan. Trans. Amer. Fish. Soc. 86:393-408.

The invasion of the sea lamprey precipitated a series of sweeping changes that are still in progress. First came the destruction of stocks of lake trout and burbot, and with it an end of predation by these fish on smaller species, principally the bloater (a cisco) and cottids. At the same time lampreys were forced to turn to the larger species and individuals of ciscoes or chubs as food. As a result, bloaters (and presumably cottids also) increased in abundance and larger chubs grew scarce. By 1954-55, the abundance of bloaters was 347 percent but that of large chubs (10 inches or longer) only 37 percent of that in 1930-32 when an earlier survey was made.

MOFFETT, JAMES W.
1958a. Attack on the sea lamprey. Mich. Conserv. 27(3):21-27.

Reviews development of the sea lamprey problem in Lakes Huron and Michigan; stresses the evidence that the lamprey alone brought collapse of the lake trout fishery in these Lakes; and warns of possible disaster in Lake Superior. A review is given of the life history of the sea lamprey and of research to develop control methods. The development and experimental use of selective toxicants are emphasized.

MOFFETT, JAMES W.
1958b. Lake trout and sea lamprey. Minn. Conserv. Volunteer 21(126):18-23.

Brief statement on the penetration of the sea lamprey above Niagara Falls and its destruction of lake trout stocks in Lakes Huron and Michigan is followed by a more detailed account of the lamprey's spread and damage to the fishery in Lake Superior. Development of control methods is reviewed from

the early attempts at mechanical blocking of spawning migrations and the capture or electrocution of recently transformed lampreys in their downstream migration, to the invention of more sophisticated electric barriers, and finally the discovery of a selectively toxic chemical. The first three field tests of selective larvicides are described.

MOFFETT, JAMES W.
1958c. Trout in the Great Lakes. U.S. Trout News 3(3):8-10.

Popular account of penetration of sea lamprey into upper Great Lakes, of its effects on fish stocks, and of research to bring about lamprey control. Details early experimentation on selective toxicants for destruction of sea lamprey larvae and touches on problems of rehabilitating late trout stocks reduced or destroyed by lampreys.

MOFFETT, JAMES W.
1960a. Attack on the sea lamprey--a report of progress. Mich. Conserv. 29(5):7-9.

Lake trout stocks of the Great Lakes were destroyed by the sea lamprey--not by overfishing, disease, other predators, or failure of food supply. Lampreys have damaged also stocks of whitefish, the larger chubs, suckers, and walleyes. For control, lampreys must be attacked in streams as spawners or as larvae. Blocking of spawning runs long offered the best means of control, but the discovery of chemicals that are selectively toxic to sea lamprey larvae has made possible the more rapid reduction of the pest. After lamprey stocks are minimized, the once plentiful, high-priced species of fish can be restored.

MOFFETT, JAMES W.
1960b. The American Fisheries Society. Its objectives: A chronicle of fishery conservation in North America. U.S. Trout News 5(4):20-22.

In his capacity as the incumbent president, author reviews origin and development of the American Fisheries Society and appraises current outlooks in fisheries.

MOFFETT, JAMES W.
1962. An instance of upwelling along the east shore of Lake Michigan, 1955. In Proc. 5th Conf. Great Lakes Res., 126. Univ. Mich., Inst. Sci. Technol., Great Lakes Res. Div., Publ. 9.

Temperature records from bathythermograph casts made during eight crossings of Lake Michigan between Ludington, Mich., and Manitowoc, Wis., Aug. 4-16, 1955, permitted description of a massive upwelling that extended 8-10 miles lakeward from the east shore. At maximum development, surface temperatures varied from 25° to 4.7° C. Persistent north and northeast winds probably caused the upwelling.

MOFFETT, JAMES W.
1963. Biological Laboratory. Amer. Zool. 3(3):374.

Gives location of the Ann Arbor Laboratory and reviews briefly the research program in relation to conditions in the Great Lakes and in the Lake fisheries.

MOFFETT, JAMES W., vide: VERNON C. APPLEGATE; ALFRED M. BEETON.

MRAZ, DONALD.
1952. Movements of yellow perch marked in southern Green Bay, Lake Michigan, in 1950. Trans. Amer. Fish. Soc. 81:150-161.

Analysis of data on recoveries in the commercial fishery of 108 of 4,172 spawning yellow perch marked in southern Green Bay in May 1950 by strap tags attached to the operculum. Recoveries indicated progressive northward movement following spawning. Fish recaptured outside the marking area averaged significantly longer than those recaptured locally. Rise of percentage return with increase in size suggested greater ability of larger fish to survive tagging or to retain tags. Marking by fin-clipping proved unproductive.

MRAZ, DONALD.
1964a. Age and growth of the round whitefish in Lake Michigan. Trans. Amer. Fish. Soc. 93(1):46-52.

Age-group III (66.3 percent) and IV (20.6 percent) dominated the catch of commercial gill nets in northwestern Lake Michigan. The round whitefish reached 12.3 inches in 3 years and 18.9 inches in 8. This growth is much more rapid than that reported earlier for the species in Lake Superior. Weight of round whitefish of Lake Michigan increased as the 3.2940 power of the length. Some males (36 percent) but no females were mature as the II group. All fish, males and females, older than age-group III were mature.

MRAZ, DONALD.

1964b. Age, growth, sex ratio, and maturity of the whitefish in central Green Bay and adjacent waters of Lake Michigan. U.S. Fish Wildl. Serv., Fish. Bull. 63:619-634.

Seven samples of whitefish (819 fish) from five localities in central Green Bay (1948-49 and 1951-52), and a single collection (204 fish) just outside Green Bay in Lake Michigan proper (1948) permitted comparisons between various points in the Bay and between the Bay and the Lake. Green Bay whitefish grew faster and were heavier, length for length, than those from Lake Michigan. The length advantage of Green Bay fish was greatest at 3 years (calculated lengths of 16.0 and 13.8 inches). The weight advantage was greatest at 9 years (calculated weights of 96.2 and 84.0 ounces). Within the Bay, growth and the length-weight relation differed among localities but differences between two samples at a single locality were equally great. The whitefish of central Green Bay was treated, therefore, as a single stock. The 1943 year class was dominant or strongly represented in all 1948-49 samples; 1951-52 collections all were dominated by age-group III. All fish older than age-group III were mature.

NIELSEN, WILLIS L., vide: VERNON C. APPLEGATE; ALBERTON L. McLAIN.

NORDEN, CARROLL R.

1961. The identification of larval yellow perch, Perca flavescens, and walleye, Stizostedion vitreum. Copeia 1961(3): 282-288.

Gives a series of characters--measurements, counts, onset of ossification of various bones--for the separation of larvae and post-larvae of yellow perch and walleye. Drawings illustrate certain differences. Pigmentation proved useful but not highly dependable as a character.

PARKER, PHILLIP S., and ROBERT E. LENNON.

1956. Biology of the sea lamprey in its parasitic phase. Fish Wildl. Serv., Res. Rep. 44, iii + 32 p.

Sea lampreys reared in aquariums through the parasitic phase grew less rapidly than wild lampreys but nevertheless attained maturity. Females made more attacks, fed more, killed more fish, and grew larger than did males. Average destruction of fish per lamprey was 18.5 pounds; in nature, this figure may be twice as great. Few fish survived lamprey attacks and most survivors later died of secondary infections.

PARSONS, JOHN W.

1958. Fishery management problems and possibilities on large southeastern reservoirs. Trans. Amer. Fish. Soc. 87:333-355.

The four main types of large reservoirs--flood control, power, storage, and mainstream--are described. In each type, the inefficient and highly selective exploitation of fish stocks offers a major problem. Management measures are listed to obtain better balanced fish populations and sounder exploitation. Commercial fishing is needed in most, if not all, reservoirs. Management of fisheries in tailwaters and tributaries also is reviewed.

PATTERSON, MATT, vide: VERNON C. APPLEGATE.

PERLMUTTER, ALFRED.

1951. An aquarium experiment on the American eel as a predator on larval lampreys. Copeia 1951(2):173-174.

A controlled experiment proved that eels located and destroyed larval lampreys in the bottom mud of an aquarium. Importation of eels is suggested as a possible method of biological control of the sea lamprey in the upper Great Lakes.

PIAVIS, GEORGE W.

1961. Embryological stages in the sea lamprey and effects of temperature on development. U.S. Fish Wildl. Serv., Fish. Bull. 61:111-143.

Eighteen developmental stages from zygote to larva are described and illustrated; comparisons are given with previous descriptions of stages. Sea lampreys were reared from artificially fertilized eggs at 5° intervals of temperature from 45° F. to 80° F. and at 52.5° and 77.5° F. No viable burrowing larvae were produced at any temperature below 60° F. or above 70° F. Optimum temperature was 65° F., which yielded 78-percent survival to the burrowing stage. Rate of development and highest stage reached are described for each temperature.

PIAVIS, GEORGE W.

1962. Exposure of several developmental stages of the sea lamprey, Petromyzon marinus, to selective larvicides. Copeia 1962(3):652-653.

Larvae of several developmental stages were exposed to a series of compounds selectively toxic to sea lampreys. Exposure of earlier stages (blastula through hatching) slowed development and led to death. Prolarvae of Stage 17 survive to Stage 18 but then die if still exposed. To assure complete destruction of young of the year, streams should be treated no sooner than 40 days after the last spawning.

POWERS, CHARLES F., DAVID L. JONES, and JOHN C. AYERS.

1959. Sources of hydrographic and meteorological data on the Great Lakes. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 314, iii + 183 p.

Lists 657 inland and 472 onshore sources of meteorological and hydrographic data. All inland (mostly weather stations) and 429 onshore (weather stations, water-treatment plants, powerplants, industrial plants, Coast Guard stations) were classed as "usable." Information is recorded on kinds of data and periods of years covered. Work done by Great Lakes Research Division, The University of Michigan, under contract with Bureau of Commercial Fisheries.

PRICE, JOHN W.

1963. A study of the food habits of some Lake Erie fish. Ohio Biol. Surv., Bull., N.S. 2(1):1-89.

Stomach contents were examined from 14,118 fish of the following species: smelt; trout-perch; yellow perch; spottail shiner; sheepshead (freshwater drum); white bass; channel catfish; walleye; alewife; and gizzard shad. According to availability of materials, information is given along the lines: diurnal variation; seasonal variation; variation by area; and variation with size of fish. Among the significant general observations were: broad replacement of the formerly important mayflies by tendipedid larvae; selection for cladocerans over copepods; importance of amphipods to trout-perch, yellow perch, and sheepshead; basically piscivorous diet for walleyes only; and significant consumption of algae by gizzard shad only. Research was under contract with the Bureau of Commercial Fisheries.

PYCHA, RICHARD L.

1961. Recent changes in the walleye fishery of northern Green Bay and history of the 1943 year class. Trans. Amer. Fish. Soc. 90(4):475-488.

The 1929-57 statistics on production, fishing intensity, and availability of walleyes are described, and the more recent fluctuations are examined in relation to evidence on year-class strength as indicated by scales of fish collected in 1949-58. The strength of the 1943 year class was phenomenal. The unprecedented abundance and the record fishing intensity it stimulated carried production to the alltime high of 1,294,000 pounds in 1950. Before it passed from the commercial fishery, the year class contributed an estimated 1,173,000 fish weighing 3,355,000 pounds. Some year classes (1945, 1946, 1948) were extremely small. The abundance of certain later year classes (1950, 1951, 1952) approached or exceeded that of the 1943 year class at the younger ages, but greatly increased mortality, attributed to sharp expansion of the sport fishery, limited their total production.

PYCHA, RICHARD L.

1962. The relative efficiency of nylon and cotton gill nets for taking lake trout in Lake Superior. J. Fish. Res. Bd. Can. 19(6):1085-1094.

Nylon nets took 2.25 times as many legal-size (1-1/4 pounds, dressed, or heavier) and 2.8 times as many undersized lake trout as cotton gill nets. These ratios agree well with those determined by earlier investigators. Mean sizes of fish in the two kinds of nets did not differ greatly, and the "efficiency ratio" had no seasonal trend.

PYCHA, RICHARD L., and LLOYD L. SMITH, JR.

1955. Early life history of the yellow perch, Perca flavescens (Mitchill), in the Red Lakes, Minnesota. Trans. Amer. Fish. Soc. 84:249-260.

Study of the life history during the first year of life with particular reference to: scale formation; body-scale relation; timing and variability of growth; length-weight relation; and food habits in relation to growth and survival.

PYCHA, RICHARD L., vide: LLOYD L. SMITH, JR.

SAWYER, PHILIP J.
1957. Laboratory care and feeding of larval lampreys. Copeia 1957(3):244.

Describes equipment and procedure whereby ammocetes were maintained in the laboratory in good condition for 6 months. Touches on: kind and size of containers and nature of substrate in them; dechlorination of water and maintenance of flow; and rearing of food organisms and schedule and procedure of feeding.

SAWYER, PHILIP J.
1959a. Burrowing activities of the larval lampreys. Copeia 1959(3):256-257.

Larval lampreys enter a substrate by a swimming motion that forces the head into it to the depth of about an inch. Additional penetration is accomplished by manipulations of the oral hood and undulatory movements of that part of the body that is within the substrate. The burrowing action is described in detail.

SAWYER, PHILIP J.
1959b. Effects of certain chemicals on mucus-producing cells of Petromyzon marinus. Trans. Amer. Fish. Soc. 88(4):305-309.

Histochemical study of mucus-secreting cells of larval sea lampreys that had been poisoned by several compounds revealed different reactions by cells from the tips of gill filaments, the lining of the gill chamber, and various locations in the epidermis. The secretory cells of the gills were without exception most sensitive to chemical irritation.

SCOTT, W. B., and STANFORD H. SMITH.
1962. The occurrence of the longjaw cisco, Leucichthys alpenae, in Lake Erie. J. Fish. Res. Bd. Can. 19(6):1013-1023.

This first report of alpenae in Lake Erie is based on 33 specimens collected in 1946-47 and 1957. Morphometric characters are compared in detail with those of L. artedi of Lake Erie. Sharpest difference is in mean number of gill rakers on first branchial arch (alpenae, 35; artedi, 46); the species differed also as to certain body proportions and growth rate.

SELDEN, CHARLES P., and HARRY VAN METER.
1960. Lake Erie walleyes-again on the upswing? Ohio Conserv. Bull. 24(1):5-7.

Account of 1959 observations on the 1959 year class, the first good year class of walleyes in Lake Erie since 1954. The lack of positive correlation between number of spawners and success of the hatch is stressed; other, still undetermined, factors seem to control year-class strength.

SMITH, ALLEN J., vide: JOHN H. HOWELL.

SMITH, BERNARD R.
1962. Spring and summer temperatures of streams tributary to the south shore of Lake Superior, 1950-60. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 410, vi + 57 p.

Spring and summer water temperatures were recorded at sea lamprey control devices in 1950-56. These data are recorded by 10- or 11-day averages as a reference source for other fishery researchers. Means of maximum-minimum readings were closely similar to single readings from pocket thermometers.

SMITH, BERNARD R., and OLIVER R. ELLIOTT.
1953. Movement of parasitic-phase sea lampreys in Lakes Huron and Michigan. Trans. Amer. Fish. Soc. 82:123-128.

Recoveries from 219 parasitic-phase sea lampreys tagged in northwestern Lake Huron totaled 38 or 17.7 percent. One was recaptured in northeastern Lake Michigan and the remaining 37 in Lake Huron. Movement was generally southward; five individuals had traveled more than 150 miles, four of them to Canadian waters of southern Lake Huron.

SMITH, BERNARD R., and ALBERTON L. McLAIN.
1962. Estimation of the brook and sea lamprey ammocoete populations of three streams. Great Lakes Fish. Comm., Tech. Rep. 4:1-18.

Larval and transforming lampreys were marked with dyes and recovered in samples of dead animals during subsequent treatments of streams with selective toxicants. Population estimates for three streams (Petersen method) were 4,200, 30,600, and 336,700 individuals. These figures confirmed broad judgments formed earlier from stream surveys with electric shockers.

SMITH, BERNARD R., vide: VERNON C. APPLEGATE; LEO F. ERKKILA.

SMITH, LLOYD L., JR., and ROBERT H. KRAMER.
1964. The spottail shiner in Lower Red Lake, Minnesota. Trans. Amer. Fish. Soc. 93(1):35-45.

Growth rates, strength of year classes, and food utilization were studied from 14,654 spottail shiners collected in 1955-57. Body-scale relations of males and females differed, and females grew faster than males. Strength of year classes was closely related to size of spawning population. Food varied according to the availability of plankton and bottom fauna, but feeding was selective. The larger spottail shiners preyed on shiner eggs.

SMITH, LLOYD L., JR., and LAURITS W. KREFTING.
1954. Fluctuations in production and abundance of commercial species in the Red Lakes, Minnesota, with special reference to changes in the walleye population. Trans. Amer. Fish. Soc. 83:131-160.

Analyses of production statistics, 1917-53, and of records of catch, effort, and abundance, 1930-53, with special respect to the principal commercial species, walleye and yellow perch. Changes of walleye abundance are independent of fishing pressure but traceable to fluctuations of year-class strength. Year-class strength could not be correlated with abundance of brood fish, abundance of competing species, hatchery plantings, or weather. Provision for prediction of abundance and flexible regulation are recommended.

SMITH, LLOYD L., JR., and RICHARD L. PYCHA.
1960. First-year growth of the walleye, Stizostedion vitreum vitreum (Mitchill), and associated factors in the Red Lakes, Minnesota. Limnol. Oceanogr. 5(3): 281-290.

First-year growth in 1940-56 fluctuated from 15.0 percent below to 9.0 above the 17-year average. The fluctuations were not correlated with water temperature, year-class strength, or the abundance of large walleyes or yellow perch. Date of spawning did affect the growth, and the length attained by the end of the first year was largely determined by size in mid-July, before the walleyes had turned to a diet of fish. Growth in the first and later years of life was correlated, but not closely.

SMITH, LLOYD L., JR., and RICHARD L. PYCHA.
1961. Factors related to commercial production of the walleye in Red Lakes, Minnesota. Trans. Amer. Fish. Soc. 90(2):190-217.

Annual fluctuation of growth that ranged from 30.7 percent above to 42.2 percent below average in 1941-56 and variations of year-class strength as great as 23-fold affected strongly the availability of walleyes to commercial gill nets. These factors, the fishing mortality of preceding years, and the seasonal distribution of fishing effort were major determinants of commercial production. Commercial catches contained age-groups II-XII but consisted principally of age-groups IV-VIII. Maximum availability is at 15.1 inches. Total annual mortality beyond that length is 0.66.

SMITH, LLOYD L., JR., vide: MARVIN D. GROSSLEIN; JOHN L. MAGNUSON; RICHARD L. PYCHA.

SMITH, MANNING A., VERNON C. APPLEGATE, and B. G. H. JOHNSON.
1960. Colorimetric determination of halogenated nitrophenols added to streams as sea lamprey larvicides. Anal. Chem. 32(12):1670-1675.

Precise knowledge of the concentration of the larvicide in the stream water is essential to effective use for sea lamprey control. A rapid procedure for determining the concentration under field conditions is based on measurement of the intensity of the alkaline color. Variations caused by changes in stream color are corrected by use of a nomograph to convert instrumental reading to parts per million.

SMITH, MANNING A., VERNON C. APPLEGATE, and B. G. H. JOHNSON.
1961. Physical properties of some halonitrophenols. J. Chem. Eng. Data 6(4): 607-608.

Certain physical properties are reported for eight mononitrophenols that are selectively toxic to sea lamprey ammocetes. Absorption maxima and molar absorptivities in the ultraviolet range and principal infrared bands are described. Acidity characteristics of the larvicides were measured.

SMITH, MANNING A., vide: VERNON C. APPLEGATE.

SMITH, OLIVER H., and JOHN VAN OOSTEN.
1940. Tagging experiments with lake trout, whitefish, and other species of fish from Lake Michigan. Trans. Amer. Fish. Soc. 69:63-84.

Analysis of data on recoveries of 388 or 13.4 percent of 2,902 fish (nearly half of them lake trout) tagged at Port Washington, Wis., to establish patterns of movement of lake trout, whitefish, lake herring, yellow perch, rainbow trout, lake sturgeon, and other species. Recaptures of lake trout were at first local but within 3 years were fairly well scattered throughout the Lake. Movements of other fishes varied from species to species. Data are included on the growth of tagged lake trout, rainbow trout, whitefish, and sturgeon.

SMITH, STANFORD H.
1954. Method of producing plastic impressions of fish scales without using heat. Progr. Fish-Cult. 16(2):75-78.

Principal features of the roller-press described are: large, 3-inch rollers that apply the pressure over a relatively wide area; micrometer adjustment for the control of the spacing between rollers; reduction gear to permit slow passage of the plastic strip between the rollers. Detailed instructions are given for the use of the equipment.

SMITH, STANFORD H.
1956a. Life history of lake herring of Green Bay, Lake Michigan. Fish Wildl. Serv., Fish. Bull. 57:87-138.

A general inquiry including data on: production and commercial importance; size, age, and growth; year-class strength; length-weight relation; distribution and movements; and sex ratio, maturity, fecundity, and spawning season and grounds. Discusses in detail the problem of "growth compensation" and the biasing effects of selective fishing on samples of the stock.

SMITH, STANFORD H.
1956b. Research vessel Cisco operations in 1955. Com. Fish. Rev. 18(5):21-23.

Brief statement of the research program in northern Lake Michigan on the abundance, distribution, and natural history of chubs, and on the limnology (hydrography, plankton, bottom organisms).

SMITH, STANFORD H.
1957a. Evolution and distribution of the coregonids. J. Fish. Res. Bd. Can. 14(4):599-604.

Theory of evolution and dispersal is based on hypothesis that Coregonus originated in northwestern Eurasia, Prosopium and Stenodus in Siberia and northwestern America, and Leucichthys in northeastern America. Variability and plasticity of forms are greatest in and near regions of origin. Species near the extremity of the range of a genus are fewer and more stable.

SMITH, STANFORD H.
1957b. Limnological surveys of the Great Lakes--early and recent. Trans. Amer. Fish. Soc. 86:409-418.

Reviews first the early explorations and casual observations and the initial limnological studies--useful but scattered and small-scale. The most effective surveys have been possible through interagency cooperation, which permits a pooling of facilities, staff, and equipment. Expansion of limnological research on the Great Lakes has been rapid in late years, and the outlook for the future is good.

SMITH, STANFORD H.
1960. Great Lakes research. Wis. Conserv. Bull. 25(2):18, 19, 22, 23.

Broad comments on the futility of attempting to understand the Great Lakes, their fish stocks, and the environment without properly designed and equipped research vessels are followed by details on the two largest research vessels of the Bureau of Commercial Fisheries on the Great Lakes, the Cisco and the Siscowet. Information is given on size, accommodations, navigational equipment, fishing gear, and scientific equipment. Past, present, and planned programs for the vessels are reviewed.

SMITH, STANFORD H.
1962a. Lake Erie or Lake Eerie? Izaak Walton Mag. 27(4):4-5.

The normal process of aging has been accelerated in Lake Erie through eutrophication from the enormous and growing inflow of sewage and organic waste. Conditions are aggravated by additions of toxic substances, siltation, and other factors. Water quality has deteriorated past the danger point. Adverse physical and chemical changes

have modified the biota; more valuable fish species have become scarce, and less desirable ones are more plentiful.

SMITH, STANFORD H.
1962b. Temperature correction in conductivity measurements. Limnol. Oceanogr. 7(3):330-334.

The usual methods of converting conductance measurements to a given temperature have not yielded uniformly accurate results because the coefficient varies according to concentration and kind of electrolytes, temperature at measurement, and temperature to which adjustment is made. Precision requires determination of temperature coefficients for each water studied. Principles involved are illustrated by data from seven natural waters.

SMITH, STANFORD H.
1964a. Status of the deepwater cisco population of Lake Michigan. Trans. Amer. Fish. Soc. 93(2):155-163.

Long-term trends in the population of ciscoes or chubs (Leucichthys [Coregonus] spp.) are reviewed, and detailed attention is given to the systematic sampling of 1930-32, 1954-55, and 1960-61. The trend toward increasing dominance by the bloater (hoyi), which started with the destruction of lake trout by the sea lamprey in the 1940's, carried the percentage of that species in gill net samples from 31.0 in the 1930's to 76.1 in the 1950's, to 93.6 percent in 1960-61. Abundance of other chubs has been sharply reduced, and two species (johannae and nigripinnis) may be extinct.

SMITH, STANFORD H.
1964b. The taxonomic status of Leucichthys macropterus, a cisco of Lake Erie. Copeia 1964(1):230.

A reexamination of the type specimen proved that L. macropterus was in fact a shallow-water cisco (L. artedii) with abnormally long fins. The count of 30 gill rakers on the first arch, given in the original description, was based on a poorly excised arch. The same arch on the other (left) side had 47 rakers. The long fins did not offer a sound diagnostic character as fish with excessively long fins, though rare, are by no means unknown among coregonids.

SMITH, STANFORD H., HOWARD J. BUETTNER, and RALPH HILE.
1961. Fishery statistical districts of the Great Lakes. Great Lakes Fish. Comm., Tech. Rep. 2:1-24.

All districts employed in the reporting of commercial fishery statistics in the United States and Canada are defined precisely, and their boundaries illustrated in accompanying charts. International and interstate boundaries also are defined.

SMITH, STANFORD H., vide: ALFRED M. BEETON; W. B. SCOTT.

TAYLOR, D. J., vide: HUBERT R. GALLAGHER.

TETER, HAROLD E.
1960. The bottom fauna of Lake Huron. Trans. Amer. Fish. Soc. 89(2):193-197.

Pontoporeia affinis was dominant in 63 bottom samples from both deep and shallow water. Next most abundant in deep water were oligochaetes, fingernail clams, and midge larvae; the midge larvae outnumbered the oligochaetes and clams in shallow water.

THARRATT, ROBERT C.
1959. Food of yellow perch, Perca flavescens (Mitchill) in Saginaw Bay, Lake Huron. Trans. Amer. Fish. Soc. 88(4): 330-331.

Of 241 yellow perch, 2.5 to 8.5 inches long, 170 had stomachs containing food. Immature insects (tendipedid larvae and pupae; mayfly nymphs) were important for fish of all sizes and made up 26 percent of the volume. Cladocerans ranked second (22 percent of the volume). Other foods of consequence were Gammarus, snails, fingernail clams, and copepods (the last especially in fish 2.5-2.9 inches long). Fish (alewives) were eaten by only 11 perch, but perch longer than those in sample are known to feed heavily on fish.

THOMAS, PAUL M., vide: JOHN H. HOWELL.

TIDD, WILBUR M., vide: STILLMAN WRIGHT.

VAN METER, HARRY D.
1960. The yellow perch of Lake Erie. Ohio Conserv. Bull. 24(11):22-23.

Popular account that reviews briefly past records of commercial production, comments on the growing importance

of yellow perch to anglers, and touches on such aspects of the biology as growth, age, and year-class composition, food habits, size at maturity, and spawning.

VAN METER, HARRY, vide: CHARLES P. SELDEN.

VAN OOSTEN, JOHN.
1923. A study of the scales of whitefishes of known ages. Zoologica 2(17):380-412.

Study of scale structure of whitefishes reared artificially in the New York Aquarium demonstrated conclusively the validity of the annulus as a year-mark. Includes data on body-scale relation and evidence that temperature is a primary factor in annulus formation.

VAN OOSTEN, JOHN.
1928a. Fisheries of the Great Lakes. Life histories of the Coregoninae. In Elmer Higgins, Progress in biological inquiries, 1926, p. 662-667. Rep. U.S. Comm. Fish. for 1927.

Comments on validity of scale method (with emphasis on the nature of Lee's phenomenon) and progress report on life-history study of lake herring of Saginaw Bay.

VAN OOSTEN, JOHN.
1928b. Scientific investigations of Great Lakes fisheries by the U.S. Bureau of Fisheries. Second Great Lakes Fish. Conf., Lansing, Mich., Feb. 8, 1928, Mich. Dep. Conserv., p. 16-20.

Outline of controversial problems of regulation in Lake Erie and description of the Bureau's experimental studies of net selectivity, which are intended to contribute toward the solution of those problems.

VAN OOSTEN, JOHN.
1929a. Life history of the lake herring (Leucichthys artedi Le Sueur) of Lake Huron as revealed by its scales, with a critique of the scale method. U.S. Bur. Fish., Bull. 44:265-428.

An inquiry into the validity of the scale method and an application of that method in a study of the life history of the lake herring (principally the Saginaw Bay stock) of Lake Huron. Critique includes an exhaustive review and evaluation of the literature and an appraisal of the author's own findings on such fundamental questions as: validity of the annulus as a year-mark; time and factors of annulus formation; body-scale relation and calculation of growth; possible causes of Lee's phenomenon and other discrepancies of calculated growth. Life-history study includes consideration of: fluctuations in age composition, size, and growth of the Saginaw Bay lake herring and possible contributing factors; growth compensation; length-weight relation; sex ratio; and differences between growth of lake herring in Saginaw Bay and in other regions of Lake Huron.

VAN OOSTEN, JOHN.
1929b. Some fisheries problems on the Great Lakes. Trans. Amer. Fish. Soc. 59:63-85.

Outline of problems and presentation of preliminary data on: effects of set-hook fishing on stocks of lake trout and of chubs used for bait; regulation of chub nets for protection of both chubs and small lake trout; protection of Saginaw Bay lake herring; biological and limnological studies; and cooperative survey of Lake Erie.

VAN OOSTEN, JOHN.
1930a. Investigation of method of measuring twine in Great Lakes district. Mich. Fisherman 14(2):1, 6.

Review of troublesome points in the controversial problem of measuring mesh size, emphasizing the need for a simple uniform procedure free from personal bias and stating that the Bureau has referred the matter to the Bureau of Standards.

VAN OOSTEN, JOHN.
1930b. Progress of fishery biology on the Great Lakes. In Elmer Higgins, Progress in biological inquiries, 1928, p. 710-718. Rep. U.S. Comm. Fish. for 1929.

Historical review of major limnological, biological, and fishery surveys of the Great Lakes by governmental agencies and educational institutions. Includes an outline of the Bureau's research program and comments on problems of overfishing and fishery regulations.

VAN OOSTEN, JOHN.
1930c. The disappearance of the Lake Erie cisco--a preliminary report. Trans. Amer. Fish. Soc. 60:204-214.

Review of production statistics on the cisco fishery and explanation of the collapse of the fishery in 1925 as the

result of overfishing with bull nets (deep gill nets) in 1923 and 1924 when abnormal weather (heavy storms) had concentrated the stocks within a small area of deep water in eastern Lake Erie.

VAN OOSTEN, JOHN.
1932a. Experiments on the mesh of trapnets and legislation of the commercial fisheries of Lake Erie. Trans. Amer. Fish. Soc. 62:100-107.

Description of experimental design and presentation of selected data to show type of results from studies of relation of mesh size to release of undersized fish and catch of legal-sized fish of several species. Recommendations are given on legal specifications for trap net meshes.

VAN OOSTEN, JOHN.
1932b. Experiments on the mesh of trapnets on Lake Erie. The Fisherman (Grand Haven, Mich.) 1(12):3-4, 8.

Summary of article published under similar title in same year in Transactions of the American Fisheries Society.

VAN OOSTEN, JOHN.
1932c. Review of Great Lakes work conducted by the U.S. Bureau of Fisheries. The Fisherman (Grand Haven, Mich.) 2(1):3-4, 8.

Review of 1927-32 activities with emphasis on the practical nature of the program and with particular reference to fishery and limnological studies on Lake Erie, experimental chub net fishing on Lake Michigan, and research on the deep trap net in Lakes Huron and Michigan.

VAN OOSTEN, JOHN.
1932d. The maximum age of fresh-water fishes. The Fisherman (Grand Haven, Mich.) 1(11):3-4.

List of maximum ages, from artificial rearing or examination of scales or other bony structures, for 44 species, drawn from the literature or based on studies by Great Lakes staff.

VAN OOSTEN, JOHN.
1933a. Preliminary report on investigation of chubnet meshes in Lake Michigan. The Fisherman (Grand Haven, Mich.) 2(4):3-4, 8.

Condensed summary of numbers and pounds of lake trout and chubs per lift of chub gill nets of different mesh size in different regions of Lake. Abundance of chubs and small trout on Michigan side of Lake, 2.7 times that in Wisconsin, was attributed to use of larger meshes in Michigan nets. Uniform adoption of 2-3/4-inch mesh was recommended.

VAN OOSTEN, JOHN.
1933b. Recent developments in commercial fishing industry. (Report of the Division of Commercial Fishing of the American Fisheries Society.) Trans. Amer. Fish. Soc. 63:31-35.

Review of developments, with special reference to the Great Lakes, in such matters as regulations and technical advances in gear, boats, processing, transportation, marketing, and the collection and analysis of statistics.

VAN OOSTEN, JOHN.
1934a. On the deep trapnet in the State of Michigan. Mich. Tradesman 52(2674): 25. A letter.

Review of the development of the deep trap net fishery showing from statistical records the dangerous increase of production of whitefish resulting from the use of the gear and the disastrous depletion of grounds fished intensively by deep trap nets. Advocates specific restrictive regulations.

VAN OOSTEN, JOHN.
1934b. The value of questionnaires in commercial fisheries regulations and surveys. Trans. Amer. Fish. Soc. 64:107-117.

Recommendation of the questionnaire as a cheap and efficient means of obtaining biological and statistical data on fish and fisheries and of learning the views of the industry on questions of management and regulation. Includes examples to demonstrate the reliability and usefulness of data from questionnaires.

VAN OOSTEN, JOHN.
1935a. First record of the alewife, Pomolobus pseudo-harengus, for the State of Michigan. Copeia 1935(4):194-195.

Report of capture of alewife in northern Lake Huron off Rogers City, Michigan--first record for the State and second for the Lake. Belief is expressed that the alewife reached Lake Huron from Lake Ontario by way of the Trent waterway and Georgian Bay.

VAN OOSTEN, JOHN.
1935b. Lake States change fishery regulations. The Fisherman (Grand Haven, Mich.) 4(10):1-2.

Review of changes of commercial fishery regulations enacted by States of Michigan, Indiana, and Wisconsin.

VAN OOSTEN, JOHN.
1935c. Logically justified deductions concerning the Great Lakes fisheries exploded by scientific research. Trans. Amer. Fish. Soc. 65:71-75.

Presentation of data to prove that logically based assumptions and popularly held beliefs are incorrect with respect to the relation between mesh size and the size and number of fish taken, the relation between fishing time and the catch of stationary gear, and the role of pollution in the decline of fish stocks in the Great Lakes.

VAN OOSTEN, JOHN.
1935d. Questionnaires prove valuable to fisheries. The Fisherman (Grand Haven, Mich.) 4(6):1-2; 4(7):1-2.

Summary of article with similar title published in 1934 in the Transactions of the American Fisheries Society.

VAN OOSTEN, JOHN.
1936a. A new immigrant comes to Michigan. The Fisherman (Grand Haven, Mich.) 5(6):1, 3.

Statement of first Michigan record of alewife, reported in 1935 article in Copeia.

VAN OOSTEN, JOHN.
1936b. Dr. Van Oosten reveals startling data. Gold Medal Netting News 9 (May 1936):1-2.

A discussion of mesh selectivity stressing that the numbers and sizes of fish taken in nets of a particular mesh size are not to be deduced on mechanical grounds but must be determined from experimentation.

VAN OOSTEN, JOHN.
1936c. Lake fisheries facing extermination. The Fisherman (Grand Haven, Mich.) 5(11):1, 3.

Discussion of unique and valuable character of Great Lakes fisheries and illustration from statistics for selected species of downward trend in production. Decline was attributed to overfishing made possible by the apathetic attitudes of State legislatures. (Article based on talk given over NBC network.)

VAN OOSTEN, JOHN.
1936d. Net selectivity on the Great Lakes. Gold Medal Netting News 10 (July 1936): 2-3.

Continuation of article in May 1936 issue of same journal, introducing data on relation of mesh size to: catches of small trout and chubs in gill nets in Lake Michigan; release of undersized fish from shallow trap nets in Lake Erie; and release of small whitefish from deep trap nets in Lakes Huron and Michigan.

VAN OOSTEN, JOHN.
1936e. The mortality of fish in Lake Erie. Great Lakes Fisherman 1(3):2, 10; 1(4):2-3; also in Pa. Bd. Fish. Comm., Combined Bien. Rep., 1938:92-100.

Analysis of the species composition of fish found dead on beaches of the south shore of Lake Erie and a consideration of the several factors that may have contributed to the mortality. Destruction of undersized fish in the sorting of the catch of commercial gears and the dumping of legal-sized fish in poor condition are suggested as the most important factors.

VAN OOSTEN, JOHN.
1937a. Artificial propagation of commercial fish of the Great Lakes. Trans. 2d N. Amer. Wildl. Conf.: 605-612. [Reprinted with slight changes of title and text in the Progr. Fish-Cult., Memo. I-131, No. 28, 1937, p. 8-15.]

General discussion of the subject, with emphasis on the facts that correlations have not been found between fry plantings and the later take of fish and that fish-culturists have underestimated the effectiveness of natural reproduction and also have failed to consider the true loss of eggs to the Lake (killing of green fish, inefficient stripping ...) attendant on artificial propagation.

VAN OOSTEN, JOHN.
1937b. Doom of the Great Lakes fisheries. Amer. Forests 43(3):103-105, 144-145.

A plea for central control of the Great Lakes fisheries, held essential to bring about the restrictions on fishing intensity necessary to put an end to the progressive depletion of the stocks of fish.

VAN OOSTEN, JOHN.
1937c. First records of the smelt, Osmerus mordax, in Lake Erie. Copeia 1937(1): 64-65.

Record of first smelt identified from Lake Erie, captured off Vermilion, Ohio, June 30, 1936, and review of several earlier and later reports of smelt indicating firm establishment of the species in the Lake.

VAN OOSTEN, JOHN.
1937d. The age, growth, and sex ratio of the Lake Superior longjaw, Leucichthys zenithicus (Jordan and Evermann). Pap. Mich. Acad. Sci. Arts Lett. 22:691-711.

Life-history study giving data on age and size distribution, growth in length and weight, growth compensation, sex ratio, length-weight relation, and condition (a negative correlation demonstrated between the growth rate and condition of individual fish). Protection of longjaw to end of sixth year of life (total length, about 10.3 inches) is advocated.

VAN OOSTEN, JOHN.
1937e. The dispersal of smelt, Osmerus mordax (Mitchill), in the Great Lakes region. Trans. Amer. Fish. Soc. 66: 160-171.

Record of plantings of smelt in the Great Lakes and a year-by-year account of the spread of the smelt through Lakes Michigan, Huron, Superior, and Erie.

VAN OOSTEN, JOHN.
1937f. The Great Lakes fisheries: their proper management for sustained yields. Trans. Amer. Fish. Soc. 66: 131-138.

Recommendations of seven-point program of regulation and research: centralized control and discretionary power; complete statistics properly analyzed; research on causes of fluctuations in abundance and yield; identification of races and studies of migrations; experimental investigations of gear; evaluation of artificial and natural propagation; and control over introductions of exotic species.

VAN OOSTEN, JOHN.
1937g. The North Central States Wildlife Conference. Progr. Fish-Cult., Memo. I-131, No. 26:15-19.

Review and evaluation of papers and discussions at the conference on such questions as: methods and values of surveys; fish populations of "type" waters and limitations of the type-water concept; effectiveness of artificial propagation and environmental improvement.

VAN OOSTEN, JOHN.
1938a. From cisco to perch to pike. State Govt. 11(3):55-57.

Review of decline of production of selected species in certain lakes with emphasis on the progressive nature of depletion in the Great Lakes, shown especially by deterioration of average quality of the catch as fishermen turned to cheaper species after depleting the stocks of the more desirable varieties.

VAN OOSTEN, JOHN.
1938b. Michigan's commercial fisheries of the Great Lakes. Mich. Hist. Mag. 22(1):3-39.

Review of fishery from earliest to modern times with respect to fishing grounds, boats and gear (construction and operation of different types described), and trends of production. Includes accounts of early statistical and biological surveys and of modern research programs and an analysis of present-day problems of regulation and management.

VAN OOSTEN, JOHN.
1938c. The age and growth of the Lake Erie sheepshead, Aplodinotus grunniens Rafinesque. Pap. Mich. Acad. Sci. Arts Lett. 23:651-668.

Life-history study includes data on age and size composition, growth in length and weight, growth compensation, length-weight relation, and condition. The large size attained by some sheepshead was shown to depend on a long life.

VAN OOSTEN, JOHN.
1938d. The extent of the depletion of the Great Lakes fisheries. Proc. Great Lakes Fish. Conf., at Detroit, Mich., Feb. 25-26, Counc. State Govt., p. 10-17.

Presentation and discussion of charts showing outstanding examples of collapse in production in Lake Erie sturgeon, Lake Superior whitefish, Lake Huron yellow perch .... Stresses fallacy of use of total production figures that do not reflect progressive shift of species composition from more valuable to coarse varieties or show effects of

exploitation of new grounds or varieties (as in the recently expanded lake herring fishery of Lake Superior).

VAN OOSTEN, JOHN.
1939a. A common concern ... Great Lakes fisheries for anglers and fishers. Mich. Game Trails 1(5):1-2.

A plea for greater interest and assistance from sportsmen and the general public to put an end to the inadequate and divided control responsible for the depletion of Great Lakes fisheries (illustrated by selected examples of decline of production from earlier "normals").

VAN OOSTEN, JOHN.
1939b. Battle rages over closing Potagannissing Bay to commercial fishermen. Mich. Game Trails 1(3):19-20.

Review and summary of 1939 report by Westerman and Van Oosten on the Potagannissing Bay problem.

VAN OOSTEN, JOHN.
1939c. Can the Great Lakes fisheries be saved? Amer. Wildl. 28(3):129-135.

Alarming account of the commercial extinction of valuable species in past years and of the current rapid depletion of still others, followed by a review of the failure of all attempts to obtain adequate regulations through interstate cooperation and an urgent appeal for support of international control of the Great Lakes fisheries.

VAN OOSTEN, JOHN.
1939d. Save the Great Lakes fisheries! Outdoor Amer. 4(3):4-5, 7.

A call for public support of attempts to obtain immediately discretionary power for conservation departments and ultimately international control of the Great Lakes fisheries. Such moves were held to offer the only means to obtain the drastic measures needed to save the fisheries.

VAN OOSTEN, JOHN.
1939e. The age, growth, sexual maturity, and sex ratio of the common whitefish, Coregonus clupeaformis (Mitchill), of Lake Huron. Pap. Mich. Acad. Sci. Arts Lett. 24(2):195-221.

General life-history study of whitefish from Alpena, Mich., area of Lake Huron including data on age compositions (III-XII represented, IV-VII most plentiful), size distribution, growth rate, length-weight relation and condition, sex ratio (about 50:50 but males scarce at higher ages), and maturity (size limit of 22 inches necessary to give immature females full protection).

VAN OOSTEN, JOHN.
1940. The smelt, Osmerus mordax (Mitchill). Mich. Dep. Conserv., Fish Div., Pam. 8, 13 p. [Revised 1948 and 1953.]

Popular account of the natural history of the smelt--habitat, spawning, growth, food, predators ... its introduction and spread in the Great Lakes, and its possible future importance as a food and sport fish and as a competitor with and predator on native species.

VAN OOSTEN, JOHN.
1941. The age and growth of fresh-water fishes. In A symposium on hydrobiology, p. 196-205. Univ. Wis. Press, Madison.

An appeal for further and more discriminating research into fundamental aspects of the scale method, a review of recent developments in the use of scale measurements for the calculation of past growth, and an outline of the numerous applications of age-and-growth studies in conservation and fish management and in taxonomic investigations.

VAN OOSTEN, JOHN.
1942a. Relationship between the plantings of fry and production of whitefish in Lake Erie. Trans. Amer. Fish. Soc. 71:118-121.

Study of correlation between whitefish fry plantings in Lake Erie and the later commercial production of whitefish. No evidence was found of benefits from plantings.

VAN OOSTEN, JOHN.
1942b. The age and growth of the Lake Erie white bass, Lepibema chrysops (Rafinesque). Pap. Mich. Acad. Sci. Arts Lett. 27:307-334.

Life-history study includes data on body-scale relation, age composition (less than 5 percent over 3 years old), size composition (62 percent below legal length of 9 inches), growth in length and weight, growth compensations, length-weight relation, condition, and age and size at maturity.

VAN OOSTEN, JOHN.
1942c. The Great Lakes fisheries: a review of the report of the International Board of Inquiry for the Great Lakes Fisheries. State Govt. 15(11):211-212, 219-220.

History of events leading to the appointment of the International Board of Inquiry for the Great Lakes fisheries, a description of the Board's activities, and a digest of the report of the full board and of the supplemental report of the U.S. members.

VAN OOSTEN, JOHN.
1942d. The Great Lakes whitefish. In U.S. Dep. Interior, Fading trails, p. 216-222. The Macmillan Co., New York.

Review of life history and habits of whitefish, account of depletion of Lake Huron whitefish by the deep trap net, and general discussion of the problem of depletion in the Great Lakes with strong appeal for support of uniform regulations and central control.

VAN OOSTEN, JOHN.
1943. U.S.-Canadian control urged to conserve Lake Erie fish supply. The Clevelander 17(10):9-10, 24.

Account of depletion in Lake Erie as illustrated by declining production of various species, discussions of need for adequate uniform regulations and of impossibility of attaining them under State control of the fisheries, and conclusion that international control is the only means of preventing collapse of the fishing industry.

VAN OOSTEN, JOHN.
1944a. Factors affecting the growth of fish. Trans. 9th N. Amer. Wildl. Conf.: 177-183.

Review of literature and appraisal of present status of knowledge of factors of growth (both fluctuations within stocks and differences between stocks) in natural waters. Includes consideration of food (natural production and food competition), space factor, temperature, and precipitation. Stresses need for better understanding of factors of growth as essential to sound management.

VAN OOSTEN, JOHN.
1944b. Lake trout. Fish Wildl. Serv., Fish. Leafl. 15, 8 p.

Popular account includes a description of the fishery in the Great Lakes and information on such aspects of the natural history as distribution, movement, habitat, feeding, spawning, length-weight relation, and age and growth.

VAN OOSTEN, JOHN.
1944c. The great smelt mystery. Mich. Conserv. 13(6):8.

Comparison of smelt production before and after the 1942-43 mortality, record of certain small postmortality spawning runs, and statement that epidemic disease provided the only acceptable explanation of the mortality.

VAN OOSTEN, JOHN.
1946. Maximum size and age of whitefish. The Fisherman (Grand Haven, Mich.) 14(8):17-18.

Presentation of records of age and size (length and/or weight) for nine whitefish (seven from the Great Lakes and one each from Lake Nipigon and Lake Champlain) from 15 to 22 or 23 years old. Old whitefish are smaller in water not fished commercially than in commercially exploited areas.

VAN OOSTEN, JOHN.
1947. Mortality of smelt, Osmerus mordax (Mitchill), in Lakes Huron and Michigan during the fall and winter of 1942-1943. Trans. Amer. Fish. Soc. 74:310-337.

Description of the spread of the mortality, evaluation of the many suggested causes (bacterial or virus disease held to offer the only explanation consistent with the facts), estimate of loss of production to commercial and sport fishermen, demonstration of improved growth of smelt following the mortality, and discussion of prospects for the recovery of smelt stocks.

VAN OOSTEN, JOHN.
1948. Turbidity as a factor in the decline of Great Lakes fishes with special reference to Lake Erie. Trans. Amer. Fish. Soc. 75:281-322.

Exhaustive treatment of the controversial question as to whether increase of turbidity due to improper land use or improper fishing has caused the decline of the Lake Erie fisheries. Review of literature on effects of turbidity on fish is followed by presentation of argument in support of conclusions: beach erosion and wind action rather than cropland erosion are principal

sources of turbidity in Lake Erie; levels of turbidity are generally too low to affect fish adversely; trends in turbidity since 1910-15 have been downward not upward as many have believed; fluctuations of turbidity have shown no correlation with fluctuations of growth and strength of year classes; and restoration of the fisheries must come through scientific fishery management--not scientific farming.

VAN OOSTEN, JOHN.
1949a. A definition of depletion of fish stocks. Trans. Amer. Fish. Soc. 76: 283-289.

A listing of situations not to be held as synonymous with depletion followed by the definition: ". . .reduction, through overfishing, in the level of abundance of the exploitable segment of a stock that prevents the realization of the maximum productive capacity."

VAN OOSTEN, JOHN.
1949b. Progress report on the sea lamprey study. The Fisherman (Grand Haven, Mich.) 17(3):6, 9-10.

Outline of program and statement of progress of cooperative researches of the Great Lakes Sea Lamprey Committee composed of representatives of the eight lakes States, the Province of Ontario, and the Bureau.

VAN OOSTEN, JOHN.
1949c. The present status of the United States commercial fisheries of the Great Lakes. Trans. 14th N. Amer. Wildl. Conf.: 319-330.

Discussion of depletion as exemplified by declining production in the face of more intensive and efficient fishing. Demonstrates from comparison of 1879-1903 and 1936-45 statistics that total U.S. yield would have decreased much more but for a large rise in the take of coarse fish. Includes data on the decline in production of important species in individual Lakes.

VAN OOSTEN, JOHN.
1949d. The sea lamprey--a threat to Great Lakes fisheries. State Govt. 22(12): 283-284, 289.

History of penetration and spread of the sea lamprey in the upper Great Lakes, records of losses of production of lake trout from lamprey depredations in Lakes Huron and Michigan, comments on the lamprey as a threat to the Lake Superior lake trout and to other species in all three Lakes, and outline of current and proposed sea lamprey research.

VAN OOSTEN, JOHN.
1950. Progress report on the study of Great Lakes trout. The Fisherman (Grand Haven, Mich.) 18(5):5, 8-10; (6):5, 8.

Outline of program of Great Lakes Lake Trout Committee (composed of representatives of States bordering the upper Lakes, the Province of Ontario, and the Bureau) and report on results of plantings of about 400,000 fin-clipped fingerlings in northern Lake Michigan in 1944-46. Includes analysis of the data on the approximately 1,200 recoveries made through 1949 with respect to movement from planting locality, time out before recapture, growth. Presents also information on similar but smaller scale experiments in Lakes Huron and Superior and on growth in Lake Michigan as determined from scale studies of samples from the commercial catch.

VAN OOSTEN, JOHN.
1953. A modification in the technique of computing average lengths from the scales of fishes. Progr. Fish-Cult. 15(2):85-86.

A demonstration that: estimates of the lengths of fish at the end of different years of life based on average scale measurements differ insignificantly from the averages of the calculated lengths of individual fish; the use of total lengths in growth calculations yields essentially the same results as are obtained when standard lengths are calculated and subsequently converted to total lengths.

VAN OOSTEN, JOHN.
1956. The lake sturgeon. In Our endangered wildlife, p. 9-10. Nat. Wildl. Fed., Washington, D.C.

Slow growth (large fish may be 150 years old or older) and late maturity (first spawning at about 20 years) made the sturgeon highly susceptible in the Great Lakes to the deliberate destruction of the early years, the later overfishing, and more recently to adverse changes of the environment. Great Lakes stocks are so reduced that extinction is threatened in some areas. Problems of restoration are difficult.

VAN OOSTEN, JOHN.
1957. The skin and scales. In Margaret E. Brown (editor), The physiology of fishes. Metabolism 1:207-244. Academic Press Inc., New York.

The structure, chemical composition, and functions of the skin of fishes and of various types of scales (cosmoid, ganoid, placoid, cycloid, and ctenoid) are described. Sections are included on: the variability in squamation; structures formed by the modification of scales and their function; and use of scales in classifications and life-history studies.

VAN OOSTEN, JOHN.
1960a. Temperatures of Lake Michigan, 1930-32. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 322, iii + 34 p.

Water temperatures were obtained at 136 stations: June 18 to Nov. 14, 1930, May 8 to Nov. 2, 1931, and April 19 to Sept. 12, 1932; numbers of vertical temperature series were 150 south of the Frankfort-Algoma line, 58 in the Lake proper above that line, and 39 in Green Bay. Discussion touches on: temperature conditions at deep and shallow stations; seasonal changes of surface, subsurface, and bottom temperatures; the shifting of 5° C. water; and formation of and gradients in the thermocline. Sections of the Lake are compared.

VAN OOSTEN, JOHN.
1960b. The true pikes. U.S. Fish Wildl. Serv., Fish. Leafl. 496, 9 p.

This popular account of the genus Esox contains morphological and life-history notes on each species. Included are such items as distribution, habitat, food, maturity, egg production, spawning, and early development. Growth data are given for muskellunge, northern pike, and chain pickerel. Concluding sections touch on artificial propagation, commercial production of northern pike and chain pickerel, and the importance of the pikes in the sport fishery.

VAN OOSTEN, JOHN.
1961a. Formation of an accessory annulus on the scales of starved whitefish. Progr. Fish-Cult. 23(3):135.

Whitefish fingerlings reared from fry in a large concrete tank (80 by 40 feet, 8 feet deep) experienced a midsummer shortage of food. Scales were examined from 11 fish removed September 22. Scales of two fish gave no indication of midsummer slowing or stoppage of growth; those of three fish had a light check; two had a "fairly good" annulus; the scales of the remaining four had a "typical" annulus indistinguishable from those formed in a natural environment.

VAN OOSTEN, JOHN.
1961b. Records, ages, and growth of the mooneye, Hiodon tergisus, of the Great Lakes. Trans. Amer. Fish. Soc. 90(2): 170-174.

The mooneye is scarce in Lakes Huron and Michigan but common in Lakes Erie and Ontario. Commercialization is limited to Ohio and Michigan waters of Lake Erie; reports of commercial catches elsewhere are errors resulting from misuse of common names. In Lake Erie the total lengths (inches) of certain age groups ran: I, 8.4; IV, 12.2; VII, 13.1. Largest fish was 14.5 inches and weighed 14.8 ounces. All are mature at 8.8 inches and 3.2 ounces.

VAN OOSTEN, JOHN.
1963. Surface currents of Lake Michigan, 1931 and 1932. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 413, ii + 51 p.

Drift bottles released were: 283 in 1931 south of a line from Frankfort, Mich., to Algoma, Wis.; 462 in 1932 both south and north of this line. Returns were: 186 (65.7 percent) of the bottles released in 1931, and 331 (71.6 percent) of those released in 1932. Indicated surface currents were variable but their general direction was from west to east--predominantly northeast in 1931 and both northeast and southeast in 1932.

VAN OOSTEN, JOHN, WILLIAM C. ADAMS, WILLIAM L. FINLEY, and FREDA. WESTERMAN.
1939. Migratory fish, a problem of interstate cooperation? Trans. 4th N. Amer. Wildl. Conf.: 25-43.

Panel discussion concerned principally with Great Lakes problems. Includes comments on the progressive depletion in the various lakes and the great difficulty of coping with the problem under the current system of divided control.

VAN OOSTEN, JOHN, and HILARY J. DEASON.
1938. The food of the lake trout (Cristivomer namaycush namaycush) and of

the lawyer (Lota maculosa) of Lake Michigan. Trans. Amer. Fish. Soc. 67: 155-177.

Analysis of stomach contents showing frequency of occurrence and estimated volume of various food items for the two species according to size of fish and region of the Lake (southern, northern, and Green Bay). Lake trout and lawyers (burbot) were found to be competitors for food, and both were predators on commercially valuable coregonids. Competition was indicated also between lawyers and coregonids for invertebrate foods.

VAN OOSTEN, JOHN, and HILARY J. DEASON.
1939. The age, growth, and feeding habits of the whitefish, Coregonus clupeaformis (Mitchill), of Lake Champlain. Trans. Amer. Fish. Soc. 68:152-162.

Comparison of samples from northern and southern areas of the Lake. The two areas were held to have distinct populations because of separate spawning grounds and differences in size and age composition, growth rate, and condition. Invertebrates made up 99.1 percent of the food in stomachs of southern Lake Champlain whitefish; mollusks (principally amnicolids) accounted for 92.8 percent of the total food.

VAN OOSTEN, JOHN, and HILARY J. DEASON.
1957. History of Red Lakes fishery, 1917-38, with observations on population status. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 229, iii + 63 p.

Historical account traces the development of the commercial fishery from its inception in 1917 through 1938. Trends of production and catch per unit effort are followed for principal species. Life-history data are given for the walleye and yellow perch. Historical accounts are provided of the artificial propagation of the walleye and whitefish from 1918 through 1938.

VAN OOSTEN, JOHN, H. J. DEASON, and FRANK W. JOBES.
1934. A microprojection machine designed for the study of fish scales. J. Cons. 9(2):241-248.

Description, illustrated by cross-section drawing and photograph, of optical equipment and general structural specifications of machine specially adapted to scale work.

VAN OOSTEN, JOHN, and PAUL H. ESCHMEYER.
1956. Biology of young lake trout (Salvelinus namaycush), in Lake Michigan. Fish Wildl. Serv., Res. Rep. 42, 88 p.

Based on collections of five mesh sizes (2-3/8 to 3 inches) of experimental gill nets fished in 1930-32. Includes information on: annual and local variation of size, age, and growth; length-weight relation and condition; sex ratio; geographical and bathymetric distribution; local and regional differences and seasonal changes in abundance; selective action of gill nets; and associated species of fish.

VAN OOSTEN, JOHN, and RALPH HILE.
1949. Age and growth of the lake whitefish, Coregonus clupeaformis (Mitchill), in Lake Erie. Trans. Amer. Fish. Soc. 77:178-249.

Analysis of production statistics, 1871-1946, to bring out long-term trends of yield and shifts in centers of production and a general life-history study including consideration of fluctuations in growth and the strength of year classes in relation to environmental condition, length-weight relation (general relation, seasonal changes of condition, loss of weight at spawning), variation of sex ratio with age and by season, age at maturity, and spawning season.

VAN OOSTEN, JOHN, RALPH HILE, and FRANK W. JOBES.
1946. The whitefish fishery of Lakes Huron and Michigan with special reference to the deep-trap-net fishery. Fish Wildl. Serv., Fish. Bull. 50:297-394.

Review of statistics on production of whitefish in all waters of Lakes Michigan and Huron, beginning with 1879, and a detailed consideration of annual fluctuations of production, abundance, and fishing intensity in local districts of the State of Michigan waters of the two Lakes, beginning with 1929, to bring out the disastrous effects of the deep trap net on whitefish stocks in those districts in which the gear was fished intensively. Includes sections on bathymetric distribution and seasonal movements of whitefish, lake trout, walleyes, burbot, and suckers, and on the fishing action of pound nets and deep trap nets (relation of mesh size to number and sizes of fish taken; gilling and bloating of live fish at lifting;

numbers of dead fish in nets; and estimates of total numbers of undersized fish destroyed).

VAN OOSTEN, JOHN, vide: HUBERT R. GALLAGHER; OLIVER H. SMITH; FRED A. WESTERMAN.

WELLS, LaRUE.
1960. Seasonal abundance and vertical movements of planktonic Crustacea in Lake Michigan. U.S. Fish Wildl. Serv., Fish. Bull. 60:343-369.

Horizontal tows of plankton nets, about 2 hours apart and spaced mostly at 10-m. depth intervals, were made from late afternoon to near midnight (through the night on two occasions) seven times in June-November 1954 and three times in June to October 1955. Data permitted description of seasonal abundance and diurnal vertical movements of eight cladocerans, nine copepods, Mysis, and Pontoporeia. Most species had a single seasonal population peak. All undertook diurnal movements but cold-stenothermic varieties did not pass through the thermocline in significant numbers. Abundance in surface waters usually was maximum near or shortly after sunset.

WELLS, LaRUE, and ALFRED M. BEETON.
1963. Food of the bloater, Coregonus hoyi, in Lake Michigan. Trans. Amer. Fish. Soc. 92(3):245-255.

Stomachs of 1,469 bloaters more than 7 inches long contained identifiable food. An additional 461 ciscoes, 7 inches or smaller, were not positively identified but without question were mostly bloaters. All fish were caught in bottom nets except 49 (less than 6 inches long) which were taken in midwater trawls. Bloaters shorter than 7 inches long depended heavily on zooplankton; larger fish fed mostly on Pontoporeia affinis and Mysis relicta. Of the two, Mysis becomes more important with increase of depth and progress of the season from spring to fall. Incidence of Mysis declines with increase in the length of fish.

WESTERMAN, FRED A., and JOHN VAN OOSTEN.
1939. Report to the Michigan State Senate on the fisheries of Potagannissing Bay, Michigan. Mich. Dep. Conserv., 82 p.

Report on study conducted in response to pressure from sport fishermen for abolition of commercial fishing in the Bay. Observations on the commercial fishery, tagging experiment on black bass, analysis of commercial fishery statistics, creel-census records . . . proved the contentions of sport fishermen concerning damage to angling from commercial operations to be invalid. Continuance of commercial fishing was recommended as desirable in this basically rough-fish water. Elimination of nets from one small area about 3 months each summer was the only change of regulation suggested.

WESTERMAN, F. A., vide: JOHN VAN OOSTEN.

WIGLEY, ROLAND L.
1952. A method of marking larval lampreys. Copeia 1952(3):203-204.

Report on successful marking of larval lampreys as small as 30 mm. long by subcutaneous injection of cadmium sulfide, mercuric sulfide, and carbon. Marks had not faded after 1 to 1-1/2 years.

WIGLEY, ROLAND L.
1959. Life history of the sea lamprey of Cayuga Lake (N.Y.). U.S. Fish Wildl. Serv., Fish. Bull. 59:561-617.

A life-history study of an endemic stock to obtain data for comparisons with the recently established Great Lakes stocks. Studies of the spawning run touched on such points as morphological characters, length, weight, time and factors of upstream migration, sex ratio, spawning sites, number of individuals in runs . . . . Incubation and habits of ammocetes were studied from specimens reared in hatchery troughs. Larval life was estimated at 7 years. Effects of sea lamprey attacks on lake trout were studied in both Cayuga and Seneca Lakes.

WILLEFORD, B. R., JR.
1956. The solubility of 3-bromo-4-nitrophenol in water and acetone. Ecology 37(4):840.

A study to solve certain technical problems in the practical application of the compound to kill lamprey larvae in streams.

WOLFERT, DAVID R.
1963. The movements of walleyes tagged as yearlings in Lake Erie. Trans. Amer. Fish. Soc. 92(4):414-420.

Of 3,998 I-group walleyes marked with a dart-type tag along the south shore of western Lake Erie in 1960,

499 were recovered over a 3-year period. Early movement was primarily northward. Later they reached extreme western Lake Erie and moved into the Detroit River, Lake St. Clair, the St. Clair River, and into Lake Huron as far as Saginaw Bay. Movement eastward into central and eastern Lake Erie was negligible. Maximum distance traveled was 236 miles; the mean was 25 miles.

WOOD, LEONARD E.
1964. Bottom sediments of Saginaw Bay, Michigan. J. Sediment. Petrol. 34(1): 173-184.

Sixty-one bottom samples were collected on a semigrid pattern and analyzed physically. Sediment size ranged from large pebbles to clay. Medium- to fine-grained clear quartz sand is common in all parts of the Bay. Currents account for median diameter and sorting. Depth and median diameter were weakly correlated. Locally abundant heavy minerals were most frequent in shallow areas subject to current action; shape also affected concentrations of heavy minerals. Roundness, sphericity, and acid-soluble content led only to general conclusions. Organic content was greatest in quiet water.

WRIGHT, STILLMAN.
1929. A preliminary report on the growth of the rock bass, Ambloplites rupestris (Rafinesque), in two lakes of northern Wisconsin. Trans. Wis. Acad. Sci. Arts Lett. 24:581-595.

Brief report on length at capture and calculated growth in length of rock bass of best represented age groups in Muskellunge and Trout Lakes. Possibility of distinct populations with differing growth rates in the latter Lake is mentioned.

WRIGHT, STILLMAN.
1932a. Conditions of life in lakes. The Fisherman (Grand Haven, Mich.) 1(8): 3-4, 12.

Discussion of the lake as a habitat and of adaptations of fish to life in an aquatic environment.

WRIGHT, STILLMAN.
1932b. Plankton and the fisheries. The Fisherman (Grand Haven, Mich.) 1(7): 3-4, 11.

Description of the principal organisms in plankton and the methods of plankton study and explanation of the significance of plankton in the production of fish.

WRIGHT, STILLMAN.
1932c. Pollution in western Lake Erie. The Fisherman (Grand Haven, Mich.) 1(6):3-4, 10.

Review of researches emphasizing the fact that harmful effects of pollution near mouths of certain rivers were counterbalanced, at least in part, by benefits from nitrogen and other fertilizing elements in pollutants. It was stated that pollution could not explain the lowered productivity of the fisheries.

WRIGHT, STILLMAN.
1955. Limnological survey of western Lake Erie. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 139, vi + 341 p.

Based principally on observations made in April to October 1929 and 1930, the report covers a limnological survey conducted with special reference to pollution. Extensive data are given on physical limnology, water chemistry, bottom fauna, phytoplankton, and zooplankton. Pollution was heavy in limited areas near the mouths of some rivers and was moderate in larger areas, but much of western Lake Erie was free of pollution. Because harmful effects of pollution were counterbalanced by beneficial effects of increased fertility, it was concluded that pollution was not a controlling factor in the welfare of the fisheries.

WRIGHT, STILLMAN, and WILBUR M. TIDD.
1933. Summary of limnological investigations in western Lake Erie in 1929 and 1930. Trans. Amer. Fish. Soc. 63: 271-285.

Report on 1929-30 study of pollution situation in western Lake Erie as indicated by chemical analyses, phytoplankton, zooplankton, and bottom fauna. It was held that the harm from the heavy pollution of certain limited areas was in some measure counterbalanced by fertilizing effects of pollutants and that pollution probably was not the controlling factor in the production of fish in western Lake Erie.

PUBLICATIONS BY SCIENTISTS ASSOCIATED WITH GREAT LAKES FISHERY INVESTIGATIONS

The following list includes the principal publications of scientists not on the staff of the Bureau's Biological Laboratory in Ann Arbor, but whose research was based primarily on materials supplied by the Bureau or was a part of a cooperative project to

which the Bureau made a significant contribution in the collection of data or through the provision of facilities. Reports on contract research are listed here when the projects were completed in large measure independently of the Laboratory.

AHLSTROM, ELBERT H.
1936. The deep-water plankton of Lake Michigan, exclusive of the Crustacea. Trans. Amer. Microscop. Soc. 55(3): 286-299.

Results of analysis of plankton from vertical hauls of 1-foot cone-shaped net (No. 20 silk) made from the research vessel Fulmar. Gives species lists, grouped in categories of relative abundance, of major phytoplankton groups, protozoans, and rotifers. Includes comments on seasonal fluctuations in abundance of certain forms.

ALLIN, A. E.
1929a. Seining records and food of the intermediate stages of Lake Erie fishes. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 188-194. Buffalo Soc. Nat. Sci., Bull. 14(3).

Record by number and species of fish taken in small number of hauls with Petersen and Helgoland trawls and with 50-foot seine and analysis of stomach contents of fish taken by seine.

ALLIN, A. E.
1929b. Seining records and food of the intermediate stages of Lake Erie fishes. In A biological survey of the Erie-Niagara system, p. 95-106. N.Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Report on same materials covered in paper issued by same author in same year under same title.

AYERS, JOHN C., vide: CHARLES F. POWERS.

BURKHOLDER, PAUL R.
1929a. Biological significance of the chemical analyses. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 65-72. Buffalo Soc. Nat. Sci., Bull. 14(3).

General discussion of biological importance of various constituents of the water and description of Lake Erie as a tolerably hard-water lake, with moderate amounts of nitrogenous substances in solution, and free of injurious depletion of dissolved oxygen.

BURKHOLDER, PAUL R.
1929b. Microplankton studies of Lake Erie. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 73-93. Buffalo Soc. Nat. Sci., Bull. 14(3).

Study of the composition, vertical and horizontal distribution, and seasonal variation of the microplankton of eastern Lake Erie. Includes lists of phytoplankton forms, protozoans, and rotifers.

BURKHOLDER, PAUL R.
1929c. Microplankton studies of Lake Erie. In A biological survey of the Erie-Niagara system, p. 60-66. N.Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Report on same materials covered in paper issued by same author in same year under same title.

BURKHOLDER, PAUL R.
1960a. A survey of the microplankton of Lake Erie. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 123-144. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

A study of seasonal, horizontal, and vertical distribution and abundance of the microplankton. Major data, given largely by maps and graphs, concern: diatoms; green algae; and blue-green algae. Comparisons of open-lake and marginal conditions are included. Comments are offered on microplankton communities. Data on Protozoa and Rotifera are limited.

BURKHOLDER, PAUL R.
1960b. Distribution of some chemical values in Lake Erie. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 71-109. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

Detailed records (including tables and graphs) are given on seasonal and local differences and comparisons of surface and bottom waters for turbidity and the following chemical characteristics: nitrogen (albuminoid and free ammonia and nitrates); dissolved oxygen; carbon dioxide; methyl-orange alkalinity; pH; chlorides. Evidences of pollution were limited to decidedly restricted inshore areas.

EGGLETON, FRANK E.
1936. The deep-water bottom fauna of Lake Michigan. Pap. Mich. Acad. Sci. Arts Lett. 21:599-612.

Preliminary paper on bottom-fauna samples collected with Petersen dredge from research vessel Fulmar in 1931 and 1932. Includes information on geographical and bathymetric distribution of the samples, list of major bottom forms, and statement of possible existence of concentration zone at about 40-50 m.

EGGLETON, FRANK E.
1937. Productivity of the profundal benthic zone in Lake Michigan. Pap. Mich. Acad. Sci. Arts Lett. 22:593-611.

Continuation of 1936 study by same author. Pontoporeia dominated the bottom fauna (65 percent of total number) and together with Pisidium and Tubificidae made up 94 percent of the total. Data given also on vertical distribution and seasonal fluctuations in numbers of bottom forms.

FISH, CHARLES J.
1929a. A preliminary report on the joint survey of Lake Erie. In A biological survey of the Erie-Niagara system, p. 39-106. N.Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Condensation of report issued by same author in same year under similar title.

FISH, CHARLES J.
1929b. Preliminary report on the cooperative survey of Lake Erie--season of 1928. Buffalo Soc. Nat. Sci., Bull. 14(3): 1-220.

Report on studies of hydrography, bacteriology, chemistry (including chemistry of pollution), plankton, and ichthyology of Lake Erie east of line from New York-Pennsylvania boundary to Long Point (Ontario). In addition to introductory and concluding pages by Fish, includes nine articles by various authors on different phases of the survey.

FISH, CHARLES J.
1960a. General introduction. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 1-3. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

Lack of knowledge of factors in the declining abundance of fish motivated this broad exploratory survey. The general characteristics of Lake Erie and its three major subdivisions are covered briefly.

FISH, CHARLES J.
1960b. General review and conclusions. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 173-198. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

Summarizes the several papers by various authors included in the report on the limnological survey. The general conclusion is offered that adverse changes in physical, chemical, and biological conditions in Lake Erie cannot account for the decline in the abundance of fish. Examination of the effects of fishing on fish stocks is recommended.

FISH, CHARLES J.
1960c. Program and itinerary. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 5-9. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

Describes cruise schedules and location of stations and outlines plan of operation for the survey which covered the eastern and central basins of Lake Erie.

FISH, CHARLES J., and Associates.
1960. Limnological survey of eastern and central Lake Erie, 1928-29. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334, iv + 198 p.

The reasons for initiation, outline of program, findings in various fields, and general conclusions are contained in a series of articles, listed and annotated separately by Burkholder, Fish, Green, Munter, and Wilson.

FISH, MARIE POLAND.
1929a. Contributions to the early life histories of Lake Erie fishes. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 136-187. Buffalo Soc. Nat. Sci., Bull. 14(3).

Preliminary report on investigations published in full in 1932 paper by same author.

FISH, MARIE POLAND.
1929b. Contributions to the early life histories of Lake Erie fishes. In A biological survey of the Erie-Niagara system, p. 76-95. N.Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Preliminary report on investigations published in full in 1932 paper by same author; similar to other 1929 report under same title.

FISH, MARIE POLAND.
1932. Contributions to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. U.S. Bur. Fish., Bull. 47:293-398.

Profusely illustrated description of various stages of early development with notes on the occurrence of young and on breeding habits of the adults. Includes directions for preparation of specimens.

GREEN, CHARLES K.
1960. Physical hydrography and temperature. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 11-69. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

Contains extensive data and discussion (supported by tables and diagrams) on surface and subsurface (reversing thermometer) temperatures. Discusses relation of these data to meteorological conditions with particular relation to subsurface water movements and seiches. Greatest attention is given the primary seiches, although other oscillations are discussed. Some data are given on currents (surface and subsurface) and on transparency (Secchi disk).

HEARD, WILLIAM H.
1962. The Sphaeriidae (Mollusca: Pelecypoda) of the North American Great Lakes. Amer. Midland Natur. 67(1):194-198.

Numbers of species recorded for the different Lakes were: Superior, 6; Michigan, 20; Huron, 20; Erie, 14; Ontario, 26. Some species are more abundant than others, and occurrence varies with depth of water and substrate.

HOUGH, JACK L.
1952. Fathogram indications of bottom materials in Lake Michigan. J. Sediment. Petrol. 22:162-172.

Fathograms obtained in Lake Michigan by commercial sonic sounding equipment showed characteristic traces for sand, till, and clay bottom. Multiple traces were correlated with specific clay strata.

HOUGH, JACK L.
1955. Lake Chippewa, a low stage of Lake Michigan indicated by bottom sediments. Geol. Soc. Amer., Bull. 66:957-968.

From the nature of core samples from various depths it is concluded that in a period identified as post-Algonquin and pre-Nipissing, the level of Lake Michigan was 350 feet below the present stage. This low-level "Lake Chippewa" drained northward through the Straits of Mackinac into a low-level Lake Huron, termed "Lake Stanley."

JONES, DAVID L., vide: CHARLES F. POWERS.

MUNDINGER, PAUL C., vide: CHARLES F. POWERS.

MUNTER, CASIMIR J.
1960. Chemical observations on pollution. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 111-122. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

Physical and chemical data (temperature, turbidity, pH, oxygen, alkalinity, carbon dioxide, chloride) from harbor areas and selected inshore stations gave no reason to believe that pollution caused decline of commercial fish stocks. Polluted areas were highly restricted. Fishes living in rivers and harbors may have been harmed and some spawning grounds could have been damaged.

PARMENTER, RICHARD.
1929a. Hydrography. In A biological survey of the Erie-Niagara System, p. 45-55. N.Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Report on same materials covered in paper issued by same author in same year under similar title.

PARMENTER, RICHARD.
1929b. Hydrography of Lake Erie. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 25-50. Buffalo Soc. Nat. Sci., Bull. 14(3).

Report on physical limnology of eastern Lake Erie including data on vertical and horizontal distribution of temperature, on currents (both the "natural flow" and currents resulting from wind, pressure gradients . . .), and on transparency.

PEGRUM, REGINALD H.
1929. Topography of the Lake Erie basin. In Preliminary report on the cooperative

survey of Lake Erie--season of 1928, p. 17-24. Buffalo Soc. Nat. Sci., Bull. 14(3).

Description of the (Devonian) rocks underlying eastern Lake Erie, of the shore topography, and the bottom deposits (principally mud and clay but with considerable stretches of sand, and some rock outcrop).

POWERS, CHARLES F., DAVID L. JONES, PAUL C. MUNDINGER, and JOHN C. AYERS.
1960. Applications of data collected along shore to conditions in Lake Erie. Univ. Mich., Inst. Sci. Tech., Great Lakes Res. Div., Publ. 5: v + 78 p.

Studies of records accumulated by municipal and industrial users of Lake Erie water suggest usefulness of the data for understanding of past changes in the Lake and monitoring to detect new ones. Informational gaps that should be filled to permit more effective use of records are listed. Work performed under contract between Bureau of Commercial Fisheries and The University of Michigan.

WILLIAMS, ROGER C.
1929a. Chemical studies of Lake Erie. In A biological survey of the Erie-Niagara system, p. 58-60. N. Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Report on same materials covered in paper issued by same author in same year under similar title.

WILLIAMS, ROGER C.
1929b. Pollution studies in the light of the chemical analyses. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 60-64. Buffalo Soc. Nat. Sci., Bull. 14(3).

Record of chemical analyses of water of eastern Lake Erie for dissolved oxygen, various forms of nitrogen, pH, CO_2, and carbonates. No evidence of harmful pollution appeared at any station in the open Lake.

WILSON, CHARLES B.
1929a. The macroplankton of Lake Erie. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 94-135. Buffalo Soc. Nat. Sci., Bull. 14(3).

Brief comments on significance of plankton in fish production followed by data on horizontal and vertical distribution of macroplankton in eastern Lake Erie. Includes annotated systematic list of organisms.

WILSON, CHARLES B.
1929b. The macroplankton of Lake Erie. In A biological survey of the Erie-Niagara System, p. 67-76. N.Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Report on same materials covered in paper issued by same author in same year under same title.

WILSON, CHARLES B.
1960. The macroplankton of Lake Erie. In Charles J. Fish and associates, Limnological survey of eastern and central Lake Erie, 1928-29, p. 145-172. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 334.

Despite enormous variability of samples taken by meter nets it is clear that the bulk of the macroplankton is made up of eight copepods, seven cladocerans, one mysidacean, and a few insect larvae. Cladocerans are most important as fish food; Daphnia pulex alone averages more than half the total. Maps show local differences and seasonal changes in the plankton. Brief summaries are given of the distribution, abundance, and ecology of different species.

ZILLIG, ANDREW M.
1929a. Bacterial studies of Lake Erie. In A biological survey of the Erie-Niagara system, p. 56-68. N.Y. Conserv. Dep., Suppl. 18th Annu. Rep.

Report on same materials covered in paper issued by same author in same year under similar title.

ZILLIG, ANDREW M.
1929b. Bacteriological studies of Lake Erie. In Preliminary report on the cooperative survey of Lake Erie--season of 1928, p. 51-58. Buffalo Soc. Nat. Sci., Bull. 14(3).

Results of bacteriological examination of water at numerous stations in eastern Lake Erie, indicating that pollution was not a factor in the abundance of fish.

PATENTS AND PATENT APPLICATIONS

United States

Disclosure: VOLTAGE MEASURING APPARATUS
Number: 2,688,116

Date: Patented August 31, 1954
Assignee: United States of America
Use: Measurement of intensity and direction of voltage gradients in fluid media, particularly natural waters; facilitates 3-dimensional plotting of electrostatic field patterns and field intensities.
Inventors: William L. Stahl and Vernon C. Applegate

Disclosure: METHOD AND APPARATUS FOR CONTROLLING AQUATIC ANIMALS
Number: 2,778,140
Date: Patented January 12, 1957
Assignee: United States of America
Use: Selective control of migratory fish and fishlike vertebrates in streams through the use of AC and DC fields of predetermined intensity.
Inventors: Vernon C. Applegate, William L. Stahl, and Bernard R. Smith

Disclosure: METHOD FOR CONTROLLING PETROMYZON MARINUS
Number: Application Serial Number 574,931
Date: March 29, 1956
Use: Control of sea lamprey populations by the chemical treatment of streams with 3-bromo-4-nitrophenol, a selectively toxic agent. Controlled applications permit destruction of all larval lampreys in a watershed without causing significant harm to other aquatic life.
Inventors: Vernon C. Applegate and John H. Howell

Disclosure: METHOD FOR CONTROLLING SEA LAMPREYS (PETROMYZON MARINUS)
Number: 2,821,499
Date: Patented January 28, 1958
Assignee: United States of America
Use: Control of lamprey populations by the chemical treatment of streams with O-ethyl-S-pentachlorophenyl thiolcarbonate, a selectively toxic agent. Controlled applications permit destruction of all larval lampreys in a watershed without causing significant harm to other aquatic life.
Inventors: Vernon C. Applegate and John H. Howell

Disclosure: APPARATUS FOR CONTROLLING THE UPSTREAM MOVEMENT OF FISH
Number: 2,913,846
Date: Patented November 24, 1959
Assignee: United States of America
Use: Guidance or diversion of fish migrating in a body of water toward a specific locale such as a fish trap, fish ladder, or diversion channel using an electric field of interrupted direct current of predetermined intensity.
Inventor: Alberton L. McLain

Disclosure: METHOD OF CONTROLLING SEA LAMPREYS WITH HALOGEN NITROPHENOLS
Number: Application Serial Number 652,316
Date: April 11, 1957
Use: Control of lamprey populations by the chemical treatment of streams with various halogen mononitrophenols. Controlled applications provide results indicated for Patent No. 2,821,499.
Inventors: Vernon C. Applegate and John H. Howell

Disclosure: METHOD FOR CONTROLLING PETROMYZON MARINUS
Number: Application Serial Number 726,021
Date: April 2, 1958; abandoned
Use: Control of lamprey populations by the chemical treatment of streams with 3-trifluormethyl-4-nitrophenol. Controlled applications provide results indicated for Patent No. 2,821,499.
Inventors: Vernon C. Applegate and John H. Howell

Disclosure: METHOD FOR CONTROLLING PETROMYZON MARINUS
Number: Application Serial Number 736,408
Date: May 19, 1958
Use: Control of lamprey populations by the chemical treatment of streams with 2-chloro-4-nitrophenol. Controlled applications provide results indicated for Patent No. 2,821,499.
Inventors: Vernon C. Applegate and John H. Howell

Disclosure: METHOD OF CONTROLLING SEA LAMPREY
Number: Application Serial Number 336,079
Date: January 6, 1964
Use: Control of sea lamprey populations by the use of chemicals selectively toxic to sea lamprey larvae. These chemicals consist of mixtures containing from 1 to

3 percent 5,2'-dichloro-4-nitrosalicylanilide and 99 to 97 percent of 3-trifluormethyl-4-nitrophenol. These two compounds form a synergistic combination which increases toxicity to larval lampreys without destroying selectivity.

Inventors: John H. Howell and Everett L. King, Jr.

Disclosure: METHOD OF CONTROLLING SEA LAMPREY
Number: Application Serial Number 340,573
Date: March 27, 1964
Use: Control of sea lamprey populations using halogenated nitrosalicylanilides, confined to a class in which the nitro group is substituted at either the 3 or the 5 position on the aniline ring. Controlled application of these compounds should permit the effective eradication of larval lampreys in a river without significant harm to other aquatic life.
Inventors: John H. Howell and Everett L. King, Jr.

Canada

Disclosure: METHOD FOR CONTROLLING PETROMYZON MARINUS
Number: 600,326
Date: Patented June 21, 1960
Assignee: United States of America
Use: Control of sea lamprey populations by the chemical treatment of streams with 3-bromo-4-nitrophenol, a selectively toxic agent. Controlled applications permit destruction of all larval lampreys in a watershed without causing significant harm to other aquatic life.
Inventors: Vernon C. Applegate and John H. Howell

Disclosure: METHOD FOR CONTROLLING SEA LAMPREYS (PETROMYZON MARINUS)
Number: 665,469
Date: Patented June 25, 1963
Assignee: United States of America
Use: Control of lamprey populations by the chemical treatment of streams with O-ethyl-S-pentachlorophenyl thiolcarbonate, a selectively toxic agent. Controlled applications permit destruction of all larval lampreys in a watershed without causing significant harm to other aquatic life.
Inventors: Vernon C. Applegate and John H. Howell

Disclosure: METHOD FOR CONTROLLING PETROMYZON MARINUS
Number: 683,165
Date: Patented March 31, 1964
Assignee: United States of America
Use: Control of sea lamprey populations by the chemical treatment of streams with 2-bromo-4-nitrophenol, 5-chloro-2-nitrophenol and their alkali metal salts. Controlled applications permit destruction of all larval lampreys in a watershed without causing significant harm to other aquatic life.
Inventors: Vernon C. Applegate and John H. Howell

Patent applications in Canada corresponding to the following United States applications have been filed in the names of Vernon C. Applegate and John H. Howell as joint inventors:

(1) METHOD FOR CONTROLLING SEA LAMPREYS WITH HALOGEN NITROPHENOLS
Application Serial Number 652,316
Filed April 11, 1957 (in the United States of America)

(2) METHOD FOR CONTROLLING PETROMYZON MARINUS
Application Serial Number 726,021
Filed April 2, 1958 (in the United States of America)

Patent applications in Canada corresponding to the following United States applications have been filed in the names of John H. Howell and E. L. King, Jr., as joint inventors:

(3) METHOD OF CONTROLLING SEA LAMPREY
Application Serial Number 336,079
Filed January 6, 1964 (in the United States of America)

(4) METHOD OF CONTROLLING SEA LAMPREY
Application Serial Number 340,573
Filed March 27, 1964 (in the United States of America)

SCIENTIFIC STAFF, DECEMBER 31, 1964

[C, Chemist; all others are Fishery Biologists]

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Leo F. Erkkila, Assistant Laboratory Director, Sea Lamprey Research

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[1] Effective January 1965, Hile and Eschmeyer left the Laboratory staff to become Editors for the Division of Biological Research.

[2] On 3-year leave to serve as Program Manager of fishery research and development on Lake Kariba, Southern Rhodesia (FAO project).

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